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Yearly Index

of the

The Blast Furnace and Steel Plant

1921

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YEARLY INDEX

JANUARY TO DECEMBER 1921

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The Blast Furnace and Steel Plant

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The Merchant Blast Furnace in 1920

Extraordinary Market and Business Conditions, in Addition to the Difficulties Encountered in the Realm of Transportation and Labor Made the Year Very Strenuous for Merchant Blast Furnaces.

By KARL F. JUENGLING,
Chief Engineer, Arthur G. McKee & Company.

THE year just passed has been a rather unusual and strenuous one for the merchant blast furnace manager. Due to the general business and market conditions in the iron and steel trades it has been necessary for managing officials to watch most carefully the business problems continually arising, and it is therefore not at all unlikely that more consideration has been given to such questions as finances, sales, labor policies, purchases, exports and other contract obligations involving future commitments, than has been given to the more technical side of design or operation.

In January, 1920, the price of foundry iron was approximately $40 per ton at Pittsburgh. During the late summer months it had risen to a nominal figure of $50, although there is reason to believe that considerable tonnages changed hands at a figure several dollars above this price. Towards the end of the year a sudden and complete reversal took place, not only in the iron and steel markets, but in other commodities as well, so that the price of foundry iron dropped in December to a nominal figure of $35 per ton and even with some makers offering tonnages for as much as $5 per ton under this price, the market was practically at a standstill.

A similar story can be told of the furnace coke market. This commodity, which is a governing factor in the production cost of pig iron, fluctuated during the year from $6 per ton at the ovens in the first months of the year, to $17 and even $20 per ton during the summer and back to $6 at the end of the year. The ore market was on a comparatively much more stable basis, due doubtless to the fact that requirements for the entire year were largely covered and delivered before the end of the summer.

In addition to such extraordinary market and business conditions, there were also similar and contingent difficulties encountered in the realm of transportation and labor.

Accordingly in reviewing developments in merchant blast furnace operations during 1920, it is very probable that most furnace managers were more concerned with guessing which way the market in raw materials and product was going to jump, with turning out tonnage and providing the most necessary improvements in almost any way possible to get results rather than to spend any great amount of time or thought in working out improvements in design or operation.

Stimulated by the general activity a considerable amount of new construction as well as reconstruction and extension has been undertaken, and, while we can point to no one marked improvement during the past 12 months in either design or construction over the previous few years, there was a widespread tendency towards giving more careful consideration to a large number of details of operation, which formerly were considered quite unimportant, and the cumulative results of such efforts at refinement will no doubt be of great benefit in the future.

In the design of the furnace itself the tendency has been to adhere to the most salient features as evolved during the past four or five years, such as the steeper bosh angle, 80 degrees or thereabouts, the comparatively larger hearth diameters, the decreased height of the bosh and the more careful proportioning of the inwall and stock lines.

The importance of the careful handling, screening and sizing of the coke and limestone has been almost universally recognized and in the new projects we find equipment or apparatus for accomplishing this purpose installed where it was formerly considered unnecessary.

There is ample evidence that the proper distribution of the charge in the furnace is being more and more appreciated, particularly with the rather indifferent quality of raw materials available during the year, and more of the rotating type of stock distributors were installed on furnaces during 1920 than in any previous year.

The labor situation has also brought to a head the importance of providing the most modern and up-to-date equipment for the handling not only of the raw materials to the furnace, but also the finished product from the furnace, and accordingly during the past year a number of skip hoist and bin systems have been added to existing hand filled furnaces. Similarly a considerable number of pig casting machines was installed to eliminate the labor involved in handling the furnace product.

Perhaps the most distinct advantage during the year in the practice of handling the cast of a furnace was the plan adopted by an eastern Pennsylvania producer, and recently placed in operation. A closed top mixer type hot metal ladle mounted on standard railway trucks and provided with a self-contained tipping device, is placed on a track directly under the iron runner. On the opposite side of this track is placed the standard pig casting machine, and after the cast of the furnace has been taken by the ladle, it is simply tipped over to the other side into the pig machine.

With this arrangement skull losses are entirely eliminated, the amount of labor necessary is very small, no switching is required except that necessary for the finished pigs, no overhead cranes are required for tilting the ladle and the first cost is considerably less than any previous installation of similar general arrangement.

More interest has been shown this year in the subject of gas cleaning than previously. Heretofore only the larger plants treated this subject seriously, but recently single furnace plants have taken steps to improve their gas conditions. The development of the various dry cleaning processes has been closely watched and very definite improvements have been made which will undoubtedly lead to their further adoption.

With the use of cleaner gas, smaller checkers in the hot blast stoves are possible and in the new plants built during the year such designs have been largely adopted. Also the cleaner gas makes it possible to adopt more refined types of boiler and stove gas burners and many such of various designs have been installed.

We have also noted a very general tendency among the merchant furnace operators to definitely improve the efficiency of their power plant operation and a considerable number have secured capable technical help whose sole duty consists in achieving and maintaining an efficiency which was previously sadly lacking and apparently possible only in the larger plants. Such procedure, together with the more general adoption and installation of a sufficient number of proper recording and measuring instruments in the power plant, will undoubtedly effect savings which will be greatly appreciated in times of more strenuous competition.

The increased freight rates and the higher price of ores of all kinds, together with the considerable accumulation of flue dust in the various merchant plants has markedly increased the interest shown in the various sintering processes and several installations of this kind are now being built.

In conclusion, we may say that the year of 1920 has been a period of close attention to purely business matters, largely to the exclusive consideration of improvements in plants and operating methods and efficiency. In this respect the industry is running quite true to form.

In time of intense production as well as in time of readjustment to new conditions and lower prices, the attention of all the leaders of the industry is imperatively directed toward the making of maximum outputs and the study of market conditions and problems of finance.

It is safe to predict that the coming year will also repeat the history of the past, at least to the extent of giving time and incentive to the development of new and better equipment and methods of manufacture, and we are already hearing rumors of expected improvement in many directions.

We confidently hope that 1921 will be a year of rapid readjustment to the new conditions, the perfecting of many new and useful improvements in the art and a return to normal conditions of the industry with a steady demand for a large tonnage at reasonable prices, a fair profit, higher efficiency of production and a truly Happy New Year for everyone connected with the industry.

Boiler Feed Water Purification

New Water Softening Plant Installed at the Blast Furnace of the American Coke and Chemical Company, Granite City, Illinois.

THE water supply for the new 500-ton blast furnace recently installed by the American Coke & Chemical Co., at Granite City, Ill., is obtained from wells. In order to keep the water consumption at a minimum, a circulating system was installed that first supplies the water to cooling and condensing equipment. It is then distributed for other uses.

The water for boiler feed is taken from the condenser hot well at a temperature of approximately 100 degrees F. The volume required is 750,000 gallons per 24 hours. This water contains approximately 15 grains per gallon of dissolved scale forming substances or the equivalent of about two pounds of scale per 1000 gallons. This hard water is delivered from the hot well to a We-Fu-Go water softening and purifying system consisting of two reinforced concrete reaction-settling tanks 34 feet in diameter by 25 feet 4 inches high, inside dimensions. These tanks are equipped with mechanical stirring devices operated by 5 hp electric motors direct connected with speed transformers to the driving gear.

Auxiliary to these reaction-settling tanks there is a small steel tank in which the reagents used in softening are mixed and from which they are delivered into the tanks by means of a steam jet pump.

Each reaction-settling tank is provided with connections through which to fill the tanks and to flush out the sludge. These connections are placed in the bottom of the tank. The flushing of the sludge from a tank needs to be done only about once per week, or when the accumulation reaches a depth of about one foot. The accumulated sludge is flushed out after a tank has been emptied to a depth fixed by the stop on the floating outlet pipe. The small volume of water remaining below the floating outlet pipe and the accumulated sludge are mixed by the stirring device, and in this condition it readily flows through the sewer connection into the sewer. The filling line is connected to the sludge blow-off line so that the stoppage of the sludge line is prevented by washing through the line every time a tank is filled.

All of the main operating valves in the connections to the reaction-settling tanks are hydraulically operated from an independent pressure system with duplicate steam pumps and a pneumatic pressure tank. The operating cocks for these valves are located on a panel in the filter house. On this panel there are also located the switches for operating the stirring device motors, and the alarm bells and switches for the high water and low water alarms which notify the operator when the reaction-settling tanks are full or empty. The reaction-settling tanks are also equipped with altitude gauges also located on the operating panel. These gauges record the time in which the tanks are filled, how long they have settled and the time in which they empty. They also record the time at which samples for testing are drawn and the time when the sludge is removed from the tanks. These recording gauges give a complete history of the cycle of operation for each tank.

The reaction tanks each hold four hours' supply of water and they are alternately filled and treated. While a tank is being filled the reagents are introduced and thoroughly mixed with the water by means of the mechanical stirring devices. After the tank is filled, the stirring devices are stopped and the water becomes static, allowing the precipitates resulting from the chemical reactions, to settle to the bottom of the tank. The softened and settled water is then drawn from the tank through a floating outlet pipe arranged to rise and fall with the level of the water. By this arrangement the travel of the pipe is automatically regulated by a stop which fixes the volume drawn and prevents the settled sludge from being drawn from the tank through this pipe. The floating outlet pipe delivers the settled water to two rectangular concrete gravity filter units with especially equipped strainer-manifold and a separate air wash system made up with brass pipe manifold. The filter beds consist of crushed quartz.

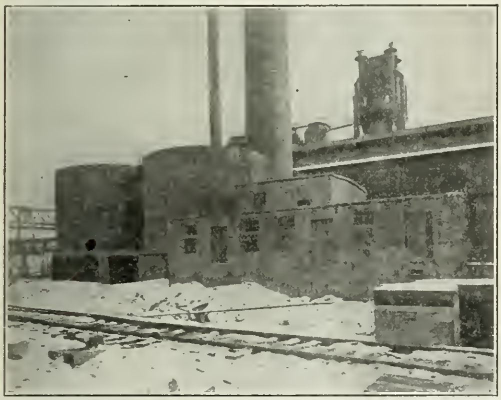


Fig. 1—Exterior view of new water softening plant.

The rate of flow from the reaction-settling tanks to the filters is automatically controlled so that they are supplied with water as fast as it is delivered from them into a purified water basin directly beneath the filters. The level of the water in this basin controls the flow from the filters, so that when the basin becomes full, the supply from the filters is automatically shut off. When this is shut off the rise of the water level in the filters automatically closes off the supply coming from the reaction-settling tanks. The purified water basin serves as a balancing tank for irregular or sudden demands for boiler feed, and the capacity is such that the requirements for boiler feed do not interfere with the proper operation of the water softening equipment as a whole. With this arrangement, uniform treatment is obtainable regardless of any variations in the rate at which the purified water is being used.

While one reaction tank is being filled, treated and settled, the other is supplying treated water. When this tank is empty the first tank is ready for use.

The filters are washed by reversing the flow of the water through them in conjunction with the agitation provided by compressed air. The wash water carrying the collected sludge is run into the sewer. The washing of the filters needs to be done only every four or five days.

Provisions have been made in the system, as installed, for increasing the capacity by adding reaction-settling tank units and filter units without changing any of the present apparatus. The accompanying illustrations show in a general outline the arrangement and structural details.

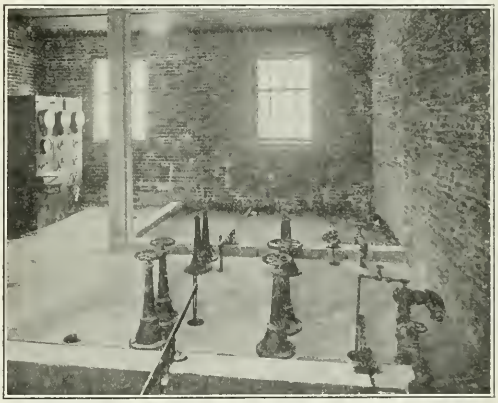


Fig. 2—General arrangement of filter house.

The method employed in softening and purifying the water in this equipment gives a maximum softening effect with a minimum of reagents, and enables the operator to have absolute control over the feed water so as to standardize it for all conditions of the raw water regardless of the rate of use in the boilers.

The softened and purified water delivered from the filters into the basin contains a total of less than two grains of silica, calcium and magnesium per U. S. gallon, and the hardness due to calcium and magnesium is less than 1½ grains per gallon. This result is constantly obtainable since the process is independent of mechanically operated features that are directly connected with the volume of water that must be supplied to the boiler feed pumps.

The water softening equipment was furnished by William B. Scaife & Sons Co., Pittsburgh, Pa., and the foundations, concrete tanks and filter house were installed under the supervision of the Engineering Department of the St. Louis Coke & Chemical Co., C. S. Lomax, Chief Engineer.

Restoring Belgium Steel Plants

Rebuilding of the Ougree-Marihaye Steel Plants, Which Were Destroyed by the Germans, Proceeding With Great Speed—Plants Are Rapidly Reaching Pre-War Production.

By GUSTAVE NEVE,
Ougree Marihaye Steel Works, Liege, Belgium.

JUST as Belgium won the sympathy of the entente nations during the war because of their courageous stand before the rush of the German armies, so they have also won the foremost admiration of the entire world after the war, because of the wonderful progress they have made in bringing their country back to its pre-war position in industrial activities.

Although the Germans occupied a large part of this country for over four years and removed and destroyed the largest part of their manufacturing equipment, they have in the course of the last year and a half rebuilt and repaired the damage done to such an extent that their industrial plants are now reaching nearly their pre-war production.

This is particularly true of the steel industry in which the Ougree Marihaye Company not only occupies the leading position in the metallurgical industry of Belgium, but is one of the foremost in the European countries. Its plants in Ougree and Marihaye, Belgium, consist of blast furnaces, steel plants and rolling mills. With its subsidiary companies it not only controls important coal mines located in Bray and Six-Bonniers, but the foundries of A. Ketin at Scilessin and the tube plant of Meuse at Flemalle-Haut. In addition it has large holdings in the blast furnaces of La Chiers, the iron works of Vireux-Molhain, the ore companies of Joudreville, Montiers and Sexey, and the blast furnaces, steel mills, rolling mills and iron mines at Rodange (Grand Duchy of Luxembourg) and its plant at Quint, near Trever.

The eight blast furnaces at the Ougree Steel Works at Liege in 1913 made 320,000 tons of iron and its steel mill production was 500,000 tons of ingots. The steel manufacturing departments supplied a total of about 15 rolling mills, the principle products of which were, sheets, iron, girders, plates, rails, axles, wire and structural shapes.

As soon as the Germans entered Belgium they took over this large steel plant with the thought of removing the machinery to Germany. This, they started out to do in very rapid manner and within a short time they had removed or destroyed the following equipment:

Four blast furnaces, out of the eight, were completely destroyed and the other four were very badly damaged; one large mixer was removed and another one was rendered absolutely useless; a Thomas steel plant consisting of 6 converters was so badly damaged that it was absolutely useless. A complete slag breaker including seven grinders and their accessories, such as boilers and power houses, was transferred to Germany. Twelve rolling mills, various shops for finishing rails, girders, plates, repair shops, testing rooms, carpenter shops, cranes, 178 electric motors of 4,500 hp and 18 gas and steam engines of 9,400 hp were taken into Germany. All together, a total of 103,351,389 tons of equipment was taken from this plant alone back into Germany.

After all the available parts had been removed, a destruction company, under the supervision of a German professor, took over the plant and destroyed the remaining parts. Photographs shown on the next page, illustrate to a small extent the amount of damage done to this particular plant. Fig. 1, rear view of the rail and beam mill before destruction; Fig. 2, rear view of the rail and beam mill after destruction; Fig. 3, front view of rail and beam mill before destruction; Fig. 5, front view of rail and beam mill after destruction; Fig. 4, finishing shop of mills before destruction; Fig. 6, finishing shop of mills after destruction; Fig. 7, view of blast furnaces Nos. 2, 3 and 5 after destruction; Fig. 8, other rear view of rail and beam mill after destruction, and Fig. 9, rear view of blooming mill after destruction.

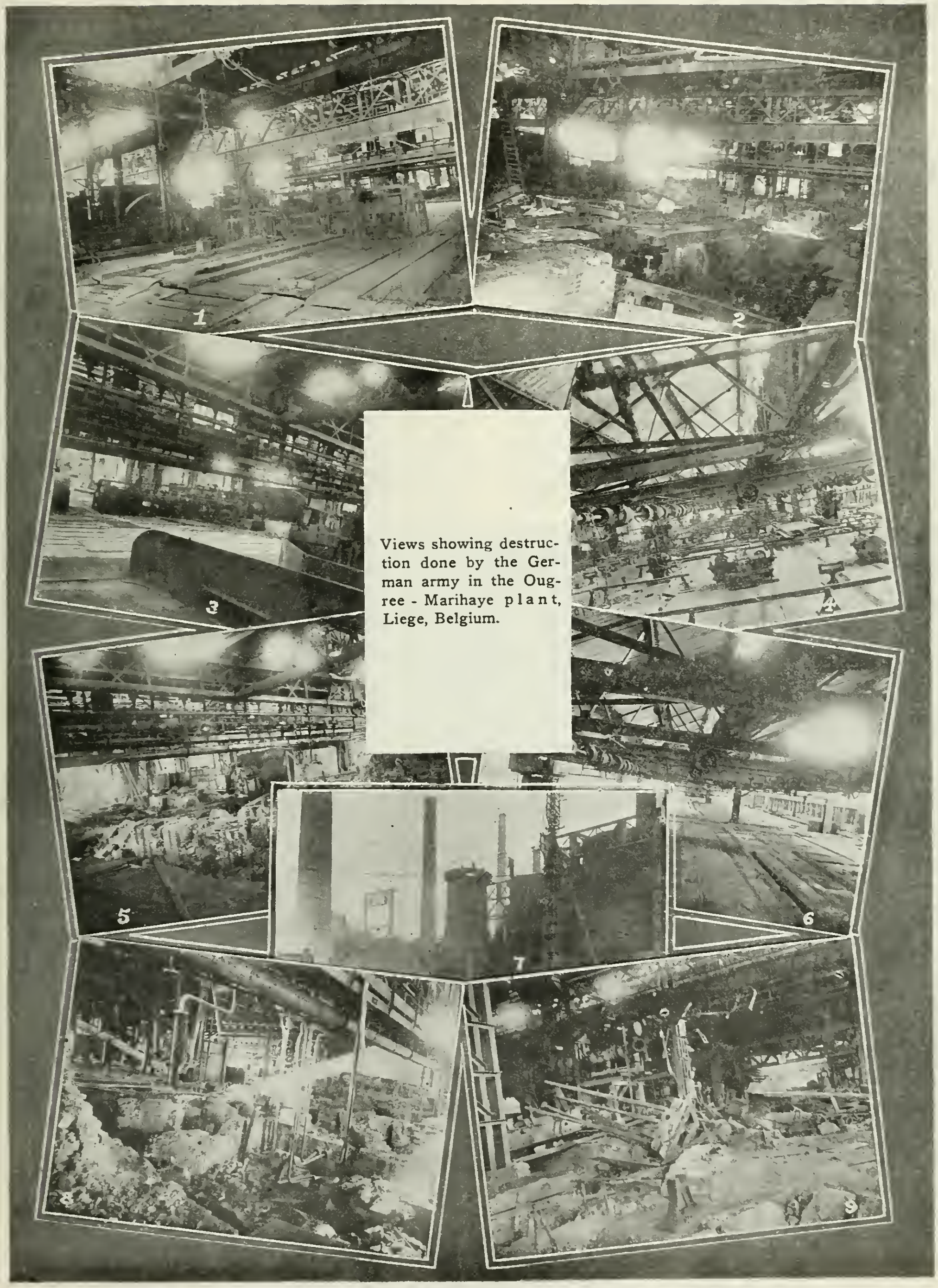
The foregoing refers only to the Ougree-Marihaye Steel Works. Other steel plants of Belgium suffered a similar destruction, as for example, the John Cockerill plant at Leraing, the Fabrique National d' Armes de Guerre at Herstal and the Providence Works near Charleroi.

However, immediately upon the signing of the armistice, the Belgiums started rebuilding these ruined plants. Although handicapped considerably by the lack of transportation facilities, shortage of raw material, restrictive legislation and regulation on economic matters, they have managed to restore their plants until they have again put the Ougree Marihaye Company in the front ranks of the European industrial plants. Four blast furnaces have been refired and their production has reached two-thirds of their 1913 production. The steel mills now consist of four Thomas retorts instead of six before the war, six open hearth furnaces instead of four before the war and an electric furnace. All together the production has reached nearly 70 per cent of its former total.

This is but an example of the energy with which one company has started to rebuild its plant. In France two blast furnaces running at La Chiers and an open hearth furnace is in operation at Vireux-Molhain. The tire mill and billet mill are also in operation at the latter plant.

At the John Cockerill plant, which was originally established in 1824, and is one of the largest industrial iron and steel plants in Europe, rebuilding has been carried on to approximately the same extent, until the plant at Seraing is now operating almost at its normal capacity.

The foregoing indicates the strides made by the Belgium steel industry toward its recovery to pre-war production basis, a fact of considerable importance to steel makers of this country, where already the influence of Belgium competition in the sale of tonnage for export has been felt.



Views showing destruction done by the German army in the Ougree - Marihaye plant, Liege, Belgium.

New Blast Furnace Built at Midland

Additions to the Pumping Station, Blowing Engine House, Power House and Boiler House Are Also Made by the Pittsburgh Crucible Steel Company at Their Midland Plant.

ONE of the several important additions to the plant of the Pittsburgh Crucible Steel Company at Midland, Pa., is that of a new 600-ton furnace. This was only recently completed and will furnish iron, in addition to that of the older furnace, to the existing 12 open hearth furnaces, and, as occasion demands, will supply pig iron to several of the various plants of the Crucible Steel Company of America, of which the Pittsburgh Crucible Steel Company is a subsidiary.

The furnace stack is 92 feet 0 inches high with a hearth 18 feet 0 inches diameter, both 22 feet 6 inches diameter, stock line 16 feet 0 inches, and bell 12 feet 0 inches diameter. The top inwall is lined with cast steel plates to resist the abrasive action of the stock. The lines of the furnace and other principal dimensions may be seen in the sectional view shown in the illustration. The design of the furnace throughout is of heavy construction, especially the hearth jacket, which consists of cast steel segments bolted together and reinforced by heavy rolled steel bands, while the cooling effect is obtained by the use of cast iron plates enclosing water pipes, placed inside the hearth jacket. The shell is supported on eight massive inclined cast iron columns, spaced alternately 36 and 54 degrees apart, the larger space occuring at the iron tap hole and the cinder notch, which are 90 degrees apart. There are 12 tuyeres, and two cinder notches 180 degrees apart. The columns are spread out at the base, resulting in an inclination greater than would ordinarily be required, to make provision for a possible future enlargement of the hearth diameter. The double skip incline bridge is supported on an independent structure, and in this manner relieves the furnace shell of any load from this source.

An electrically operated McKee automatic distributor is provided with separate control for six skip four station and six skip six station cycles. This control

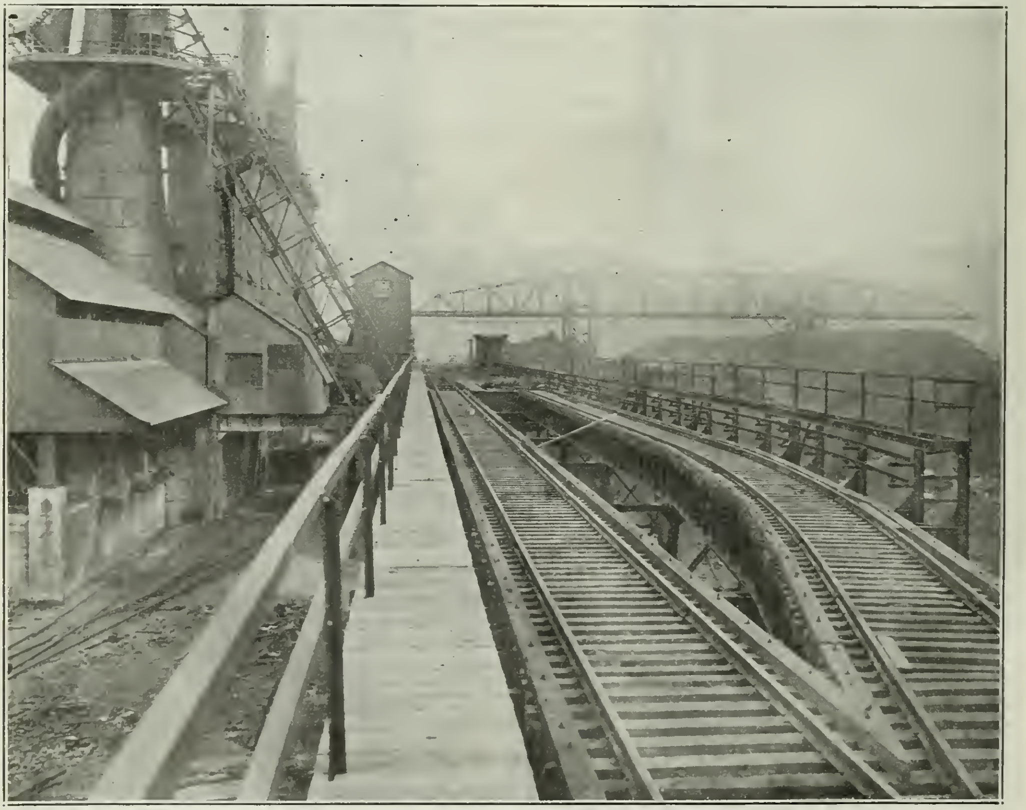


Fig. 1—General view of blast furnaces, high line, ore bridge and ore yard.

is located in the hoist house and is directly connected with the drum shaft of the skip hoist. Both large and small bells are operated by utilizing air from the cold blast main, while an independent auxiliary source of supply is obtained from a high pressure air line in case of emergency due to lack of sufficient pressure in the cold blast main. The hoist house is located just under the skip incline bridge between the furnace and the coke bins, and above the cinder car tracks, and contains an Otis electrically operated double skip hoist, with automatic control boards for the hoist and the McKee distributor, in addition to the cylinders which operate the large and small bell. Ample room is provided to store a spare armature for the hoist as well as other repair parts. The operation of the hoist, sounding rods, and bell indicators is controlled by the operator placed on the level of the scale car floor of the stock bins at a point convenient to observe the filling of the skip cars. For convenience in handling repair material on top of the furnace there is provided a 25-ton movable trolley and a 3-ton rotative jib crane. The cast house is equipped with a 15-ton electric overhead traveling crane.

Stoves for New Blast Furnace.

Three 2-pass side combustion stoves are used, 23 feet 0 inches diameter, 105 feet 0 inches high, containing 294,000 square feet of heating surface. The checker flues are 4¾ inches square; and the size of the brick 6 x 2½ x 12 inches. The stoves are served by a single stack 7½ feet in diameter, 200 feet 0 inches high. One Berkholtz-Terbeck burner and two revolving chimney valves are furnished with each stove, and the relief valve is connected directly to the underground flue common to stoves and stacks. A combined passenger and freight elevator running to the top platform of the stoves, a distance of 92 feet 6 inches from the base of the stoves is placed near the stack for the convenience of the workmen. This elevator, which has a 5 by 7 foot platform, has a capacity of 2,500 pounds and is electrically operated at a speed of 100 feet per minute. A stairway, divided into short flights, surrounds the elevator tower, and affords another means of access to the top platform.

Gas Cleaning.

After the gas leaves the dust catcher, which is 25 feet 0 inches diameter by 35 feet 0 inches high, it is conducted to a nine unit Kling-Weidlein dry cleaner capable of cleaning the dust from the gas of both furnaces. The surplus gas which is not used at the stoves is utilized under the boilers. At necessary points in the gas mains, Kling-Weidlein goggle valves are placed to afford a quick means of controlling the gas, and to sentionalize various parts of the gas system.

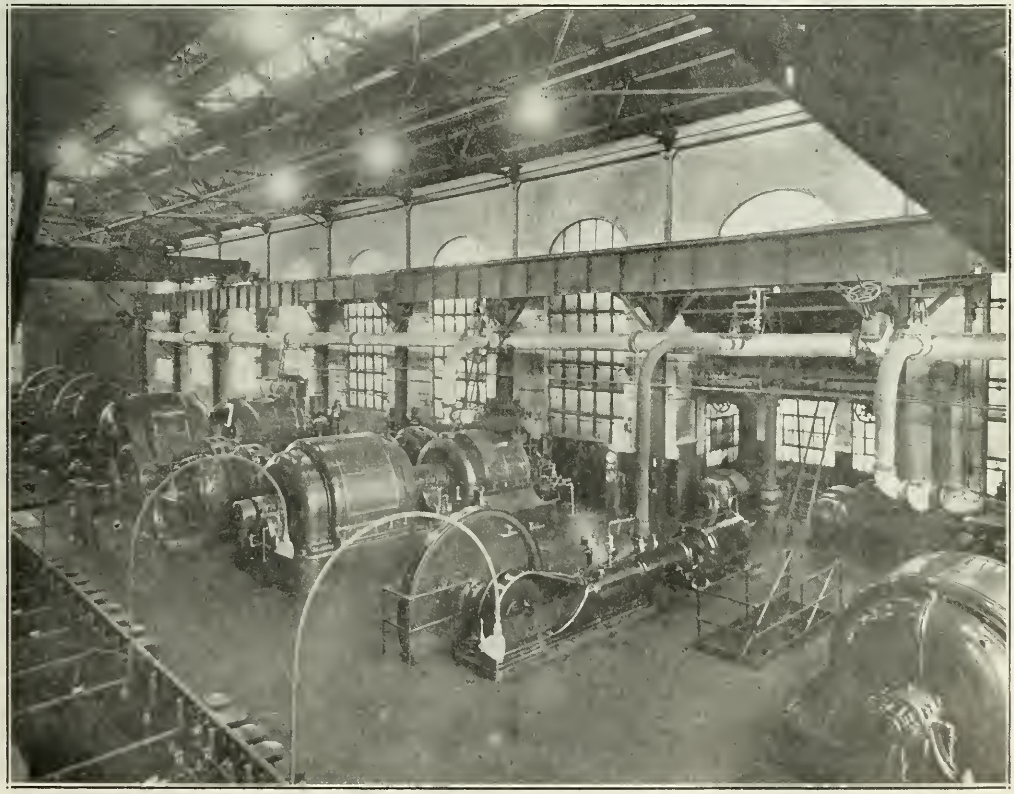


Fig. 2—Interior view of a section of the power house.

Coke and Ore Bins.

Stock from the ore yard is delivered to Hoover Mason ore and coke bins, consisting of 10 double stock pockets spaced 14 feet 0 inches on centers and one central coke bin located directly above the furnace skips. The bins are of heavy type steel construction with double louvers and 5-foot 0-inch drums on each side. Two double compartment scale cars are used capable of withstanding charges up to 30,000 pounds, equipped with bottom doors of manganese steel. The cars are operated with 35 hp railway type motors with standard drum controller and are furnished with standard indicating and recording apparatus. The usual standard method of operations for this type of bin has been adopted.

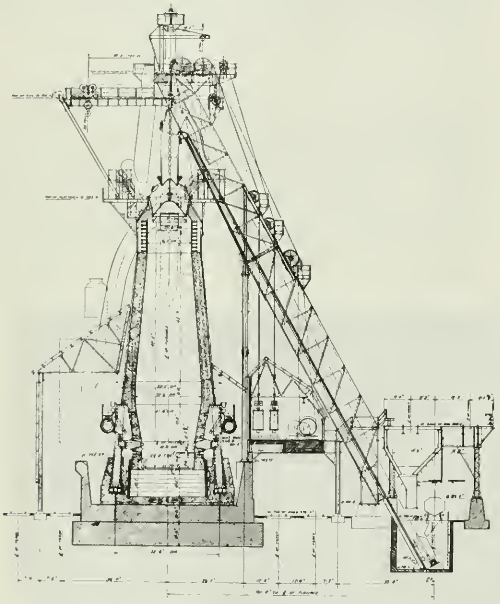


Fig. 3—Section of the furnace.

Car Dumper.

The raw material is received on cars by a Wellman-Seaver-Morgan movable car dumper electrically operated. The track on which the car dumper travels is 1,750 feet long and runs parallel to the ore bridge yard which covers a length of 2,005 feet between bridge cable anchors. With the erection of the new blast furnace it was found necessary to increase the extent of the ore yard which is about double that which it was formerly and now has a maximum storage capacity of 1,300,000 tons.

The car dumper is arranged for handling all types of open top railway cars in sizes ranging from 6 feet 6 inches to 12 feet 0 inches high, width up to 11 feet 0 inches, and an overall length of 54 feet 0 inches. The maximum capacity of cars which this machine is designed to handle will have a total weight, cars and contents, of 280,000 pounds and dumping speed may be regulated to give a capacity of 30 cars an hour. The travel speed of the entire machine along the runway is 75 feet 0 inches per minute. A slight modification from the usual standard design for the machinery housing was necessary on account of interference due to the overhang of the ore bridge. This interference was eliminated by discarding the usual housing which embraces the entire machinery floor and covering only the motors and adjacent machinery with a small housing. The frame work of this machine was also modified to the extent of making the distance between end posts several feet greater than previous designs in order to provide for the possible use in the future of longer cars than are at present used.

From the car dumper the stock is unloaded into a concrete receiving pit running parallel to the entire length of the runway, whence it is removed by two traveling bridges of Hoover Mason design (one having a capacity of 15 tons and the other of 7½ tons) to the respective stock piles. This reduces the travel of the ore bridges to a minimum as the car dumper deposits the stock directly opposite the stock piles. Again in charging the bins at the furnace the bridge is placed over the pile of desired stock and the bucket deposits its load into a 60-ton Hoover & Mason ore transfer side dump car which travels on an elevated steel trestle at an elevation of 32 feet above the yard level, the tracks of which are an extension of those on the stock bins. The trestle is double tracked at each end for a short way, the shorter track next to the ore yard extending a sufficient distance from the stock bins to control the delivery of ore required for the second furnace and to reduce the travel of the ore bridges to a minimum. The longer track extends the full length of the trestle, a distance of approximately 1,165 feet to the coke bin at the recently completed coke oven plant. After the coke is delivered to this bin from the coke ovens it is conveyed to the central coke bin at the furnace by means of a one side delivery coke car manufactured by the Atlas Car Mfg.

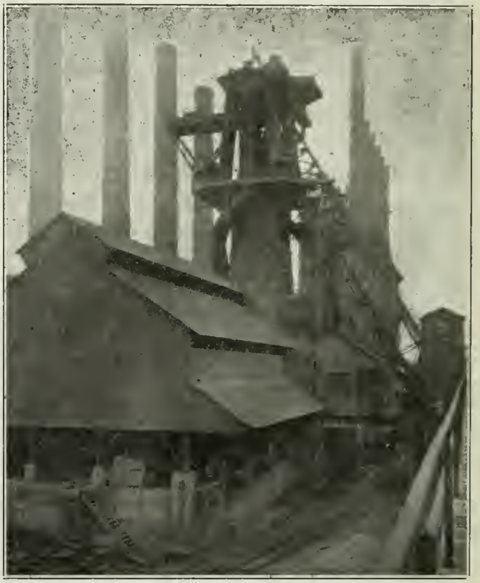


Fig. 4—View of the blast furnace.

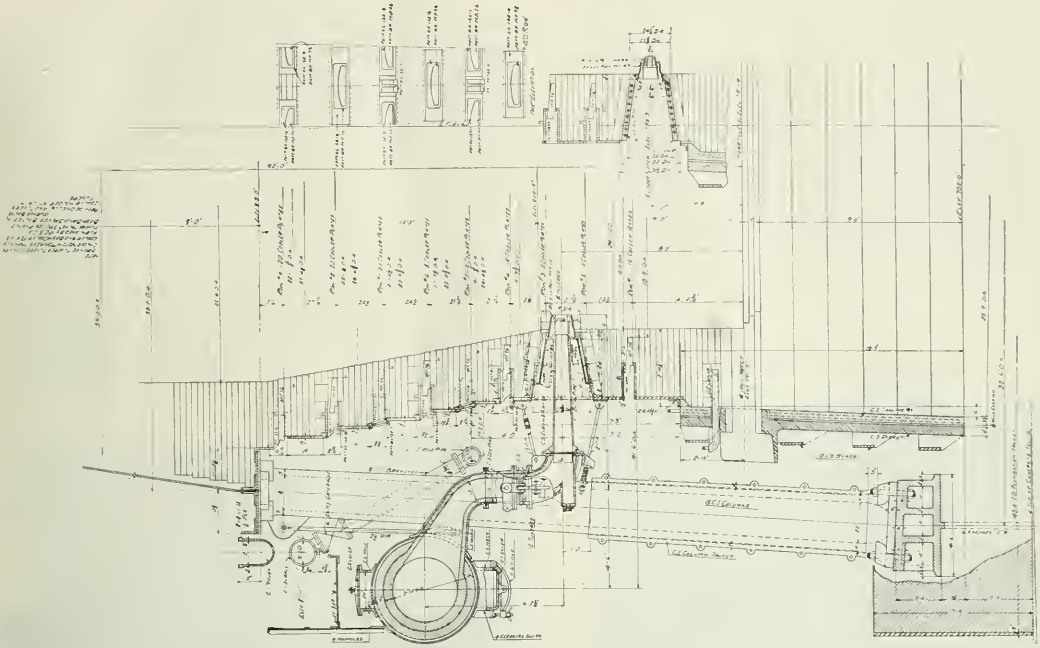


Fig. 5—Section through the bosh.

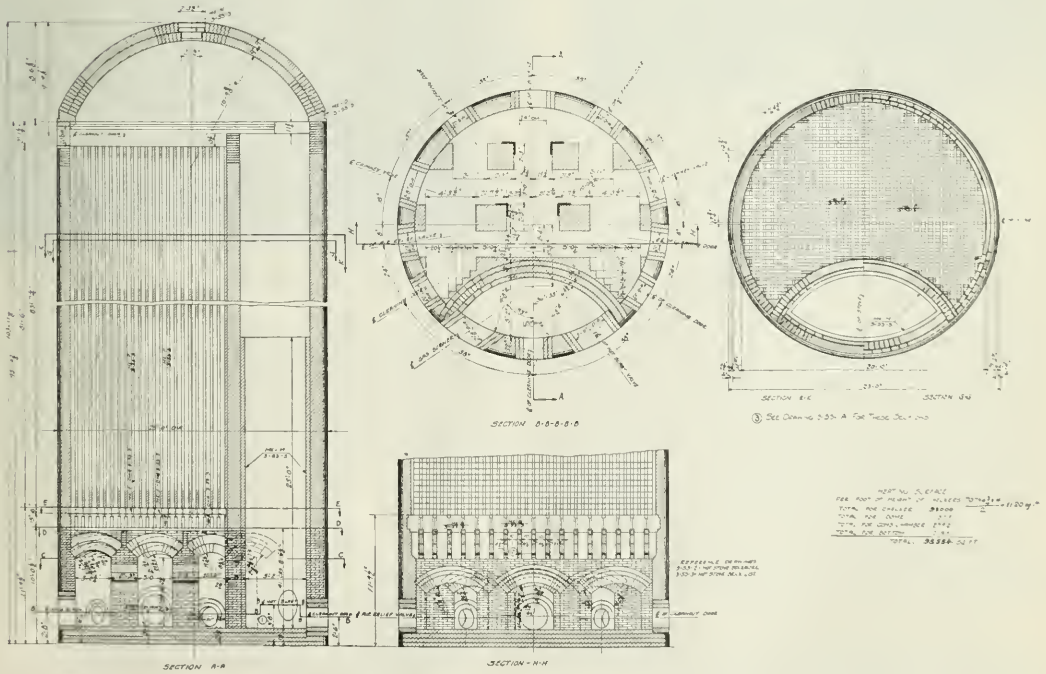


Fig. 6—Section through the stoves.

Company, and has a hopper capacity of 2,100 cubic feet and a weight capacity of 30 tons. This car is electrically operated and is provided with two 59 hp railway type motors, with a cab on each end for housing the operator and control equipment. The total weight of car and load is 80 tons.

The coke from the central bin enters the skip buckets through chutes which contain manganese screening plates. The coke braize is collected below the screens on one side of the skip bridge by a receiving hopper, which also receives the braize from the other side by means of a 16-inch belt conveyor, crossing under the skip bridge. From this hopper the braize passes into a self measuring bucket which in turn deposits its contents into a skip tub of 27 cubic feet capacity. On the pressure of a button, the tub is elevated on an inclined runway by means of an electrically operated hoist, and the braize dumped into a storage bin of 80,000 pounds capacity placed along side and above one of the cinder car tracks. When a sufficient quantity of braize has accumulated in the storage bin, it is discharged into a car through two chutes with gates controlled by hand levers operated on the ground level. The hoist control is so arranged that one pressure of the button results in a complete cycle of operation, consisting of raising, dumping and lowering the tub, and the automatic filling of the measuring bucket.

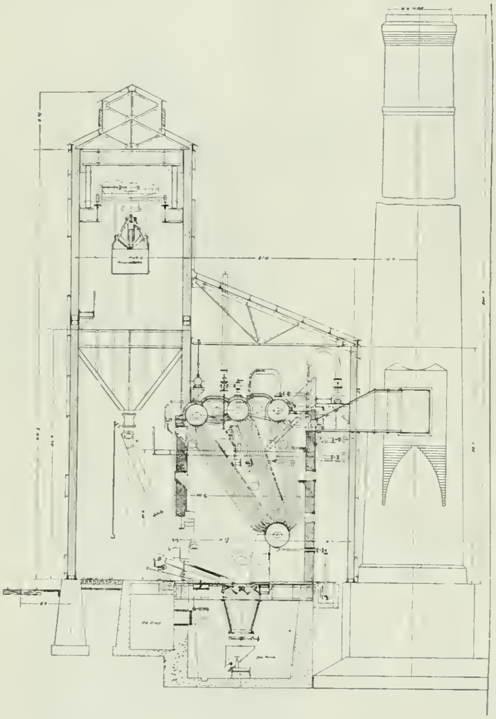


Fig. 7—Section through the boiler house.

The erection of the new blast furnace required an extension of the existing boiler, power, pump, and blowing engine houses, to all of which additions were made of a greater or less proportion.

In the blowing engine house the equipment was increased by a 42 and 84 and 84 and 84 by 60 inch horizontal compound blowing engine made by the Mesta Machine Company, having the high pressure steam valve gear of double valve type for superheated steam, and the low pressure steam valve of the Corliss type, designed to be operated at 175 pounds steam pressure and 100 degrees superheat. It is intended to operate at a normal speed of 60 rpm, and a maximum of 75, with a normal air pressure of 18 pounds and a maximum of 25 pounds. A Richardson Phoenix automatic oiling system of a capacity of 500 gallons per hour furnishes the means of lubricating this engine, and the engines furnishing air for the old blast furnace. An independent cold blast main runs to each furnace and the arrangement is such that the cold blast may be delivered to either furnace from the new blowing engine or the two older engines. All engines are served in common by one 96-inch type "A" Helander barometric condenser and one 12 x 24 x 21 inch dry air pump.

Pumping Equipment.

The main pumping station, located on the Ohio river bank, was extended and equipped with two DeLaval and one R. D. Wood single stage vertical pumping units, each with a capacity of 15,000,000 gallons per 24 hours, operating against a maximum head of 135 feet including suction. Four of the pumps are direct connected with General Electric motors of 550 hp supplied with alternating current of 6,600 volts to run at a speed of 720 rpm. The total capacity of the pumping station including the two older pumps is now 75,000,000 gallons per day of 24 hours. To provide against a breakdown of the alternating current lines, and to insure at all times a partial supply of water to the plant, especially to the blast furnace and open hearth furnaces, one of the five motors is connected to the 230 volt direct current system.

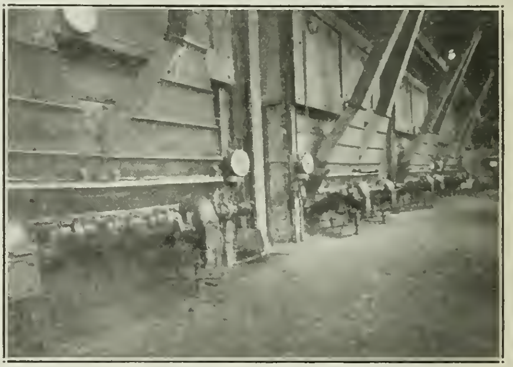


Fig. 8—Interior view of boiler house.

A 10-ton Toledo crane has been installed, equipped with 16 hp, and 3 hp electric motors for the hoist and trolley travel, while the bridge travel is controlled by hand.

The intake wells are provided with two Rex vertical traveling water screens, manufactured by the Chain Belt Company, each driven by a 10 hp direct current motor.

The auxiliary pump house which supplies water to the 100-foot standpipe for general service was increased by the addition of two De Laval 16-inch single stage double suction horizontal type centrifugal pumps, each mounted on a common bed plate and direct connected by means of a flexible coupling to a DeLaval turbine equipped with a standard governor. When operating at a speed of 1,200 rpm each pump will deliver 7,000 gallons of water per minute against a total gage head, including suction lift, not greater than 15 feet of 105 feet, with an efficiency of not less than 78 per cent, requiring 238 brake horse power.

The generating capacity of the power house has been more than doubled by the installation of a 12,500 K. V. A. General Electric turbine generator set, operating on 3 phase, 25 cycles, and 6,600 volts, the excitation of which is obtained by means of a direct connected 75 K. W. 250 volt generator. The turbine exhausts into a Westinghouse LeBlanc low level jet condenser, equipped with a 270 hp non-condensing steam turbine, with provision for the future of a direct connected motor drive. Cooling air is supplied to the generator by means of a 33,000 cubic feet per minute air washer No. 6-D type "A" manufactured by the Carrier Air Conditioning Company. Provisions are made to take the incoming air from the outside or inside of the building and to discharge it partly or entrely to the outside of the building as conditions may require. A 1,000 kw motor generator set was installed to take care of additional demands of the new blast furnace equipment. For voltage regulation a duplicate K-24 Tirrell regulator is installed. The turbine generators are "Y" connected with the neutral grounded through resistance. A double bus, double switching system has been employed, using General Electric type H-3 oil switches and auxiliary equipment. From the power house duplicate lines are run to six substations through underground cable feed system.

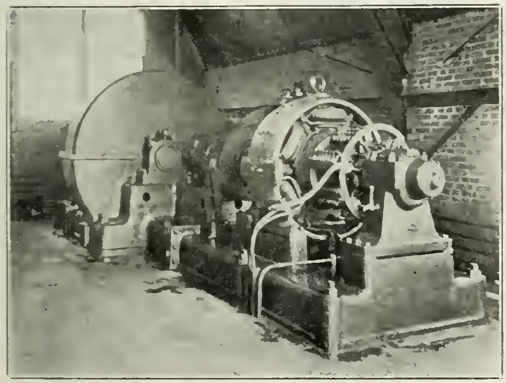


Fig. 9—View of Otis Skip Hoist.

Boiler House Extension.

The boiler house is an extension to the old blast furnace boiler plant and consists of seven 823 hp class M-30 Stirling boilers, designed to operate at 22 pounds gauge pressure. Each boiler is equipped with Foster superheaters, giving 100 degrees F. superheat to the steam. There are four perforated Radical brick chimneys 9 feet 6 inches diameter by 200 feet high, erected by the Rust Engineering Company, each designed to remove the flue gases from two boilers. Space has been provided for an eight boiler, which will complete the battery.

Boilers Nos. 1 and 2 are each fired with six 10-inch Berkholtz-Terbeck blast furnace gas burners of the aspirating type with combined primary and secondary air inlets. Boiler water is fed to each boiler by a type "A" Stets boiler feed water controller, designed for a differential pressure of water and steam of 15 pounds, the boilers to operate from 100 to 150 per cent of rating. The blast furnace gas is delivered to the old and new gas fired boiler from the gas cleaners through a 7 foot 9 inch I. D. brick-lined steel main at a temperature of about 350 degrees F. and a pressure of about 8 inches of water.

Boilers Nos. 3, 4, 5, and 6 are each fired with Westinghouse underfeed stokers of 8 rotors each, designed to burn slack coal, and are chain driven from a line shaft under the floor. A Westinghouse Engine, size 5 by 6 inches is installed at each end of this line shaft, also chain driven, and each engine is equipped with a Ruggles-Klingermann governor, which increases or decreases the engine speed as the steam pressure varies. One engine acts as a spare. Each stoker dumps ashes into a 275 cubic feet cast iron ash hopper, equipped with twin arrow ash gates, which in turn empties into a Koppel steel hopper ash car of 40 cubic feet capacity. This car is electrically operated, travels through the ash tunnel under the boilers and discharges into an outside ash pit. This pit is directly under a Morgan three-motor traveling trolley bucket crane, operating a 4 cubic yard Blaw Knox speedster type grab bucket, which hoists the ashes into an overhead brick-lined ash bin, equipped with chutes to discharge ashes directly in hopper or side dump cars.

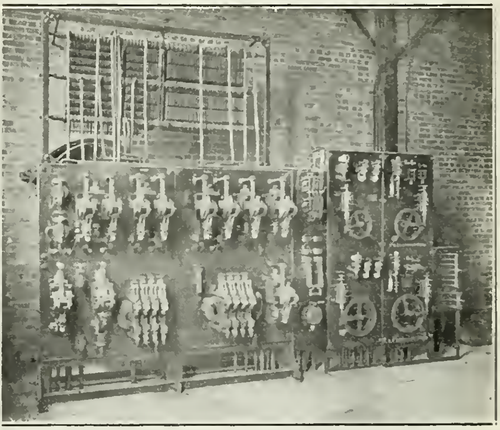


Fig. 10—Switchboard controlling hoist and top of the furnace.

Boiler No. 7 is fired with a Coxe stoker, designed to burn coke braize, is motor driven and equipped with a Detrick arch with fantail ignition arch. This stoker discharges into a 260 cubic feet ash hopper, which empties into the ash car.

Boilers Nos. 3, 4, 5, 6 and 7 are equipped with type "A" Stets boiler feed water controllers, designed for a differential pressure of water and steam of 15 pounds, with the boilers operating from 150 to 300 per cent of rating. These boilers are also equipped with Vulcan Soot Cleaners, each consisting of a two-inch system of six revolving elements.

Each boiler is equipped with a Bristol recording flue gas temperature gauge and three Hays draft gauges. One of these is a direct reading gauge indicating the air pressure in the forced draft air distributing ducts, and two are differential gauges, one showing the draft in the furnace and the other the draft either at the breaching connection to the boiler in front of the damper or the draft loss from the furnace to the damper.

The flue gas is analyzed by the Hays automatic recording CO instrument, so designed that it may record the CO_2 from any one of the seven boilers. In order to analyze flue gas from the blast furnace gas fired boilers as well as from the coal and coke braize fired boilers, the range of the instrument is up to 30 per cent. In connection with the recording instrument, a Hays Portable Gas Analysis instrument is used to check the CO_2, CO and O2 in the flue gases.

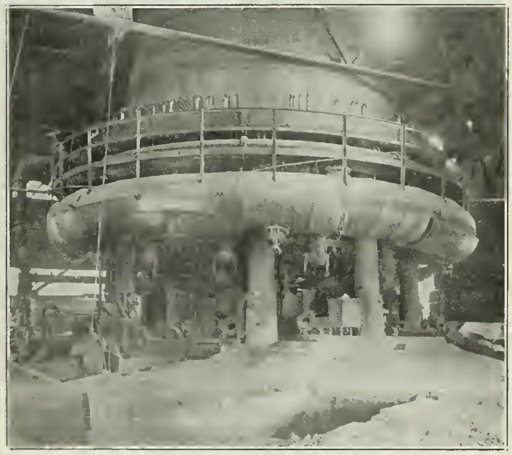


Fig. 11—General view of the furnace.

Boiler feed water is heated in a Cochrane elliptical metering heater, with exhaust steam from the boiler plant forced draft fan turbines, the boiler feed turbines, stoker engines, and the auxiliary pump house turbines. An adjustable 24-inch Cochrane multiport relief valve protects the heater from excessive pressure. The capacity of this heater is 328,000 inches per hour, equivalent to 10,933 hp continuous operation. The V-notch meter wier is designed to pass water at the rate of 500,000 pounds per hour with a maximum rate of 625,000 pounds per hour. The meter consists of a V-notch weir and float, directly connected to an indicating, integrating and recording instrument with a 24 hour chart clock enclosed in a dust and moisture proof steel case. This meter is elevated so that it will give a positive head of 8 feet to the boiler feed pumps. To record the water temperature, a Bristol recording temperature gauge is connected to the inlet and outlet of the heater. The water is delivered to the boilers by three DeLaval 3-stage 8-inch single suction hydraulically balanced boiler feed pumps, each mounted on a common cast iron bed plate with and direct connected by means of a DeLaval flexible coupling to a 258 bhp DeLaval turbine equipped with an excess pressure governor and Copes differential pressure pump governor. One pump will serve the new boiler plant, one the old boiler plant, and the third will act as a spare.

Air is delivered to the five stoker fired boilers by three No. 5½ "R. B." double inlet radial flow forced draft Green Fuel Economizer fans, of 64,000 cubic feet per minute capacity each, against five inches water pressure. Each fan is directly connected to a size 3-C, solid type, Kerr turbine, rated at 100 hp at 1,150 rpm. Two fans to operate for maximum load, one to be a spare. Each turbine is governed by a Ruggles-Kleingermann governor which increases or decreases the turbine rpm as the steam pressure varies.

Fuel is received in two pits, one for coke braize and one for slack coal. Hopper cars drop the flue through 3-inch screens into chutes which discharge directly into the pits. The fuel is then hoisted and dropped into the individual bins above and in front of each stoker fired by the Morgan trolley crane and Blaw-Knox, 4 cubic yard grab bucket.

Steam is delivered from each boiler through an 8-inch pipe to a 16-inch loop header. Each 8-inch pipe is equipped with a Crane non-return valve and a General Electric steam flow nozzle for metering steam flow. At the side of each boiler is a General Electric steam flow meter of the indicating and recording type. The steam distribution lines from the 16-inch loop header to the shops, coke oven plant, auxiliary pump house, blast furnace, blowing engine, power house and 12-inch tie line, connecting the blast furnace and blooming mill boiler plants, are equipped with Republic steam flow pitot tubes and meters of the indicating, integrating and recording type, electrically operated, and located in the boiler plant pump room. Bristol recording steam pressure and temperature gauges are installed on each end of the header. This is necessary because the header is designed so that the coke oven plant may be operated with two or three boilers separate from the rest of the plant, and not receive the steam pressure fluctuation due to change of blast furnace and mill operations.

ENGINEERS FORM NEW STEEL WORKS SECTION.

Approximately 100 members of the Engineers Society of Western Pennsylvania in an annual meeting held January 12, at the William Penn Hotel, Pittsburgh, voted for the formation of a steel works section as approved by the board of directors, December 21. W. C. Hawley, Pennsylvania Water Company, Wilkinsburg, Pa., discussed reconstruction and repairing problems encountered in waterworks engineering. Preceding Mr. Hawley's address, which was illustrated, officers were elected as follows: President, G. H. Danforth, Jones & Laughlin Steel Co.; vice president, M. O. Knowles; treasurer, A. Stucki; secretary, K. F. Treschow. The new members of the board of directors are: L. F. W. Hildner and George T. Ladd.

Gases Obtained in Molten Steel

Dealing With the Gases Which Manifest Themselves During Steel Making Operations—Classification of the Gases and How to Deal With Them in Order to Make the Product Sound.

By HENRY D. HIBBARD.

PART II.

1. Gases in and evolved from molten decarburized iron. Molten desiliconized iron made by an oxidation process, which may be considered as unfinished steel, is always charged with gases, in some cases perhaps as plentifully as soda water with carbonic acid gas. These gases escape in bubbles which rise through the slag causing the so-called "boil" which gives by its peculiarities important information to the melter concerning the state of bath, though it is extremely difficult to describe. There is a proper boil for finishing each kind of steel according to its carbon content and whether it is to effervesce or be killed. For working out an excess of carbon a more vigorous boil is desired than for finishing. The addition of iron ore increases the boil for a given carbon. Generally speaking, the lower the carbon the less the vigor of the boil, and when that element is very low, say under 0.05 per cent, relatively few bubbles escape though the metal is heavily charged with gas. Stirring the bath with a bar of iron liberates these gases in great volume and they burn as they issue from the baths with what resembles the blue carbonic oxide flame. H. H. Campbell found these gases to consist largely of carbonic oxide, or 82 per cent in one determination. The greater volume of CO with the lesser content of carbon in the metal and the diminished boiling action indicate that the CO is in solution in the iron, that is, that all CO did not leave the metal immediately upon formation but remained dissolved.

Silicon in the metal in the open hearth bath protects the carbon from oxidation and will therefore, when present, lessen the vigor of the boil. Such a condition may occur in working on an acid hearth high carbon steel, such as that for springs, the higher carbon calling for proportionately more pig iron in the charge which adds more silicon at the same time. With 0.25 per cent of silicon the bath will lie dead and require the addition of ore to oxidize the silicon and bring on the boil to remove any excess of carbon which must be driven out to give the desired composition.

The gases in molten iron which is to be made into solution steel should be gotten out of it as far as practicable before the final additions are made, as those remaining will then be more fully dealt with by the solvents added and, freedom from gas holes will be favored. Stirring and boiling are about the only means for dislodging these gases or some of them which may be contained to the point of saturation or near it.

In making effervescing steel on the other hand, ample supplies of CO gas must be allowed to remain in the metal to give the desired action in the molds.

Many years ago excessive stirring was practiced at a steel works in this country in making soft open hearth steel, 30 rods of iron or steel one inch thick being used on a 20-ton charge. The practice was discontinued after a while as it was considered not to improve the steel. At that works, however, good effervescing steel was not made either with or without stirring as all the low carbon steel rose in the molds.

2. Gases in and evolved from molten steel. Low carbon effervescing steel is first considered, the gases, by the correct amount of oxidation, properly limited use of solvents and right casting temperature, being caused to escape freely from the steel in the molds. These gases have been found to be chiefly carbonic oxide, but to contain a considerable proportion of hydrogen and some nitrogen as well. The volume of these gases is many times the volume of the ingot. The proper rate of their evolution is such that the steel neither rises nor falls as it solidfies, but the ingot has a flat top when all frozen. The casting temperature has a great effect on the rate of evolution of these gases. In proportion as it is too high the rate diminishes to the detriment of the product, when the steel is far too hot there may be no evolution of these gases whatever, but the steel rises in the molds, due to the displacement of the metal by the profusion of skinholes formed, which will be considered later.

If the steel is over-oxidized the volume of these mold-evolved gases may be excessively great. Soft basic steel which fills a mold at the end of teening may settle down to half or even less of the height of the ingot as the gases escape leaving a shell or "bootled" of the shape of the upper half of the mold attached to the fairly solid base. Thus with the gas getting out of the metal as fast as it can the bubbles still within the liquid metal, equal half or more of the volume of the steel in the mold.

The carbonic oxide gas in escaping from the steel probably carries off with it a considerable part of the hydrogen, both of that which is dissolved in the metal and that which has begun to collect in gas holes clinging to the freezing walls and which is unable to escape by itself. Presumably it carries off some of the nitrogen as well.

When air is exhausted around such molten steel to form a vacuum the evolution of gas is greatly increased. Bessemer tried it 60 years ago with the result that the outrush of gas was so copious that over 90 per cent of the molten metal was thrown out of the crucible which contained it. Baraduc-Muller* extracted from mild basic Bessemer steel in one trial 16.5 volumes of gas of which the average analysis was:

Carbonic dioxide, CO_2	3.6
Oxygen	.9
Carbonic oxide CO	30.5
Hydrogen	52.2
Methane, CH_4	.2
Nitrogen	12.7

This quantity of gas amounted by weight to 0.13 per cent of the steel or 3.9 pounds per ton. This steel was made when the weather was fine and the air consequently dryer than the average. He found that in rainy weather when the air held more moisture the volume of gas was 25 times that of the steel and presumably it contained a considerably higher percentage of hydrogen. He also found that the percentage of CO diminished and that of hydrogen increased as the vacuum became more nearly perfect, which agrees with the work of others who have found the gas evolved from open molds to be chiefly carbonic oxide.

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*Iron and Steel Institute. C. S. M., 1914.

Muller claimed that carbonic oxide is insoluble in solid steel, basing his conclusion on his failure to find it in the gases he obtained from cold steel. This claim is supported by the way in which CO escapes from good effervescing steel. The failure of CO to escape from excessively hot would be effervescing steel can apparently only be due to its decomposition, because of the high temperature of the bath, by the manganese added, with the formation of oxide of manganese, the liberated carbon being dissolved in the metal. In good effervescing steel the manganese added diminishes greatly the volume of CO in the metal and which is evolved, but at the lower temperature the decomposition of the CO is only partial, enough being left to make the effervescing desired. When, in some certain practice the evolution of the addition of from 2 to 5 ounces of aluminum to the ton of steel in the ladle is made to lessen its vigor, though the larger amount mentioned is likely to cause a settle hole or short pipe at each ingot top which is not wanted in such steel. Probably less ore with gentler boil in the furnace at the end would make aluminum additions unnecessary.

Though manganese apparently has the effect on CO noted, it has little or no power to keep hydrogen in solution. In effervescing steel the hydrogen separates in bubbles which cling to the cooling walls and grow as the walls increase in thickness unless dislodged or swept away by the mechanical action of the rising CO bubbles. So when the CO is decomposed, and therefore cannot cause effervescence, and no solvent for the hydrogen is present, skinholes are formed and the steel rises in the molds.

Silicon, aluminum and titanium seemingly have equal or greater power than manganese to decompose CO, but they have in addition power to hold hydrogen, nirtogen and their derivatives in solution, and are therefore used as solvents in making solution steel, preventing the escape of gas and the formation of gas holes. A well-made charge of low carbon steel which would effvesce properly if allowed to do so is of higher carbon steel would rise, moderately, may be made into solid solution steel ingots by the addition of 0.2 or 0.3 per cent of silicon and 0.02 or 0.03 per cent of aluminum. Well-made solution steel does not evolve gas during teeming, though when melted and exposed to the air as in the stream from the ladle a little burning gas, presumably CO plays over its exposed surface.

3. Gases which occupy gas holes and pipe cavities. From the character and location of the different kinds of gas holes which occur in steel ingots, it is evident that they are caused by different gases or mixtures of gases. Those common to ingots may be divided into three varieties, according to their situation in the ingot, which we will call skin, intermediate and central holes, other kinds peculiar to castings will also be considered later. Good effervescing steel contains intermediate and central holes, but steel which effervesces too little or too gently may have skin holes as well as the other two. Partly killed steel, if it rises, may have any or all of them. If it stands it is likely to have only skin holes and central holes. Well-made solution steel should of course settle perfectly and have no gas holes whatever.

The gases which occupy these different kinds of gas holes have never been separately analyzed, but there is much reason for believing that the skin holes are caused and occupied chiefly by hydrogen, the intermediate by carbonic oxide, (CO), and the central by nitrogen and ammonia (NH_3) with perhaps some admixture of CO.

The first variety, skin holes (also called subcutaneous holes), always constitute defects in steel when they occur, when they are close to the outer surface of the ingot as they usually are, they are liable to become coated inside with oxide of iron during the ingot heating operation, the oxide remains imbedded in the steel during forging or rolling and constitutes "seams" in a bloom or bar or "pits" in a plate. Numerically they may vary from a few near the bottom of a low carbon ingot or the top of a higher ingot, (with, say, over 0.5 per cent carbon) to a profession which covers the whole ingot on every side as closely together as the cells of bees honeycomb. They are elongated with axes normal to the mold wall, vary in length from about ½-inch to 2 inches, and in diameter from 1/16 to ¼-inch. Ingots which contain them close to the surface are called in the shop "thin-skinned", as the skin is usually burned through in the heating furnace. In pronounced cases the surface of the hot-worked bar or plate is simply an aggregation of defects and the piece wholly unsalable so that it must be scrapped.

These skin holes by displacing metal cause the steel to rise in the molds, sometimes, for several minutes after teeming has been finished, their total volume being anything up to 12 per cent of that of the ingot, and the rising is an indication of their presence. The top of the cold ingot will therefore show by the successive layers formed as the rising steel has overflown and frozen, when they are plentiful, though mild cases may not be so recognized. As stated there is ground for believing the gas in these holes to be chiefly hydrogen.

The gas is liberated from the freezing metal sometimes with force enough, when the mold is closed at the top to raise the mold and ingot, bodily, which might require a pressure on the ingot bottom of at least 50 pounds per square inch. In extreme cases the mold cover has been burst off with almost explosive force, or jets of liquid steel squirted out to the danger of those near. This should not happen.

(Continued in March issue)

AN INFORMATIONAL SERVICE CONCERNED WITH METALS AND ALLOYS.

An Alloys Research Association is being formed with an Alloys Informational Service as the first step. This is to be coöperative on the part of those interested in metals and their alloys. An advisory committee, composed of 17 prominent technical men, was formed some time ago and this committee has evolved a plant, in conference with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, whereby a service of a different scope from any now existing can be carried on for the benefit of the alloy men. It has been felt that it is time to broaden the sources of knowledge and to have a coöperative service that will critically and analytically digest the great mass of data that has been accumulated, but is now largely inaccessible.

Heating Furnaces and Annealing Furnaces

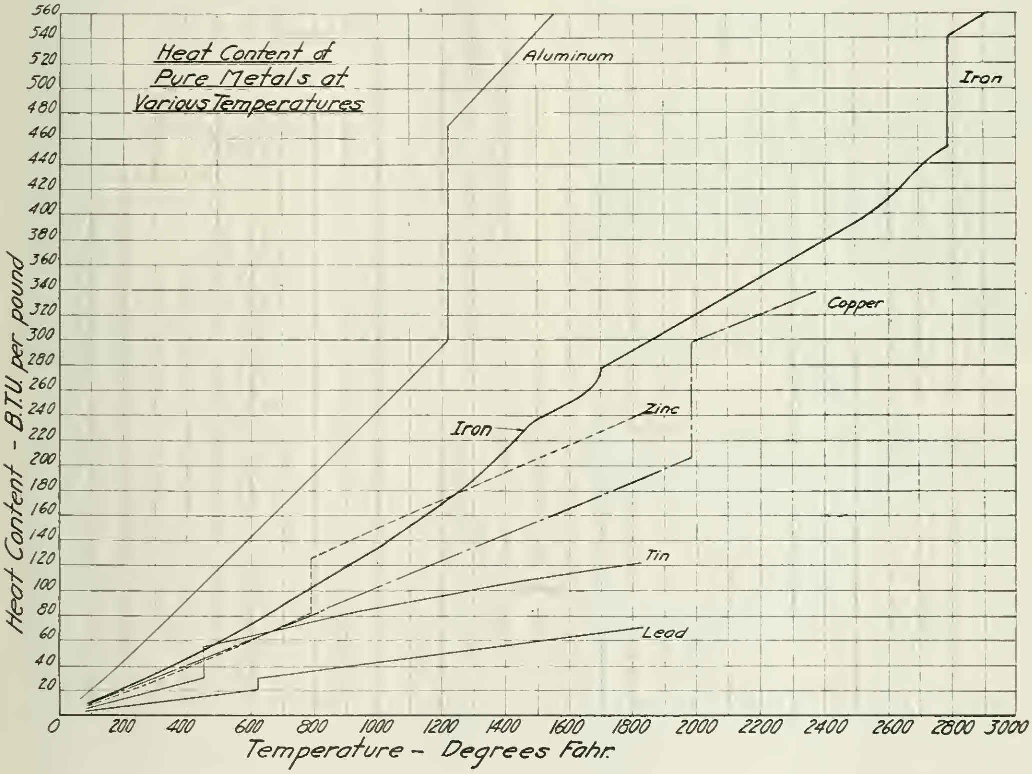
Results of Recent Investigations on the Thermal Capacities of Various Metals—Temperature Distribution in the Interior of Heated Steel Bodies.

By W. TRINKS.

PART XXVI.

TO complete this series of essays on heating furnaces and annealing furnaces, it will be necessary, first, to fill in some gaps left by previous articles, and second, to give a critical comparison of the different types of furnaces.

In part one, the heat content of a pound of pure iron was given as a function of the temperature. In the meantime, the Society of German Engineers has published work on the thermal capacities of the most important metals.* Fig. 198 shows the result of this research work. Unfortunately, no tests are available which show whether the heat content of steel varies to any great extent with the carbon content or with alloying elements, such as nickel, chromium, etc.



Fg. 198—Heat content of pure metal.

In using the values of Fig. 198 for estimating the capacity of a furnace for heating different metals, it should be remembered that the conductivity of the different metals must also be considered.

The effect of conductivity on the time required to heat a piece of metal more or less uniformly will readily be recognized from the following study. If a piece of cold steel is put into a hot furnace, the furnace temperature drops, and the surface temperature of the steel rises rapidly, with the temperature of the center of the steel lagging behind. A strictly accurate mathematical investigation by analytical methods of the temperature distribution in the steel is impossible, at least with the present-day status of mathematics. On the other hand, the subject of temperature distribution in the interior of steel which is being heated is of sufficient practical importance to warrant an investigation. As a sufficiently close approximation, the curves of Figs. 199, 200 and 201, are offered. They were obtained by a point-by-point integration. The curves of Fig. 199 represent the surface temperature of a long steel bar of 1-inch diameter, which is suddenly thrust into a furnace, the wall temperature of which is equal to and held at the value marked on any of the curves shown in the chart. For instance, a surface temperature of 1100 degrees F. is reached in 14 minutes, if the furnace temperature is 1200 degrees F., it is reached in one minute and 20 seconds if the furnace temperature is 3,000 degrees F. If a bar 2 inches in diameter is put into the furnace, the time which is required to reach a given surface temperature will be approximately twice as long as that which is required for a 1-inch bar. As before mentioned, the temperature of the center of the bar lags behind the surface temperature, and the amount of the lag is shown by Fig. 200. If, for instance, a 1-inch bar is put into a 3,000 degrees F. furnace, its surface will have reached a temperature of 700 degrees F. after 3/4 of a minute, with a temperature difference of 63 degrees F. between surface and center.

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*Forschungs-arbeiten auf dem Gebiete des Ingenieurwesens, Heft 204; Die Temperatur-Warmeinhaltskurven der technisch wichtigen Metalle, by F. Wust. Heat content is also shown therein for chromium, molybdenum, tungsten, platinum, bismuth, cadmium, antimony, silver, gold, manganese, nickel and cobalt.

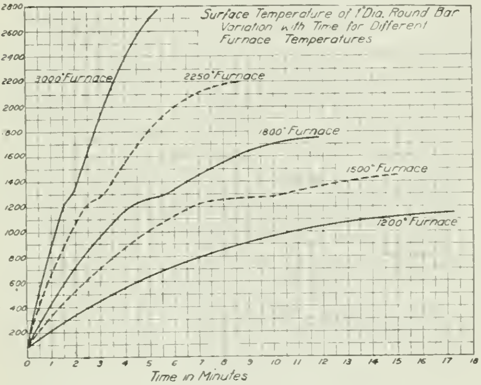

Fig. 199.

The curves are of great practical importance. If bars are to be heated to 2,000 degrees F. for an operation which requires greatest uniformity, say for instance, not more than 10 degrees F. difference between center and outside, then a 2,250 degrees furnace will do and the heating time will be a little over six minutes. If, on the other hand, a temperature difference of 30 to 40 degrees F. is permissible, then a 3,000 degrees F. furnace may be used and the heating time may be cut down to three minutes. It goes without saying that, in the latter case, the steel must be removed quite promptly from the furnace, if overheating or even melting is to be avoided.

The use of the curves presupposes that the furnace temperature is not appreciably pulled down by the charging of cold steel. Chilling action is reduced by making the interior brick surface of the furnace large compared to the surface of the steel being heated, or else by filling the furnace with a white hot, incandescent flame. The latter has the advantage that, in case of interruption of operation, the steel can be protected from overheating by shutting off the flame, whereas, in the case of heat transmission from large, white-hot brick surfaces, interruption of heat flow is not possible, except by removal of the steel from the furnace.

The final outcome of this condition is that the excess of furnace temperature which can be continuously maintained above the final steel temperature depends to a large extent upon the ratio

$$\frac{\text{surface of furnace interior (brick)}}{\text{surface of steel being heated}}$$

Tentative curves for that relation are given in Fig. 201. The curves show that steel cannot be heated to 2,200 degrees F. continuously in a 3,000 degrees F. furnace, unless the ratio of brick surface to steel surface is 8 to 1 with a non-luminous flame, or 5 to 1 with a highly luminous flame. The curves as before stated, are tentative. They were based upon theoretical calculations and were checked by a few practical observations. They may be modified by additional application and checking. It has been repeatedly stated in this series that, everything else, including ratio of brick surface to steel surface remaining equal, the heating time of a bar is directly proportional to its diameter. To this statement may now be added another one, namely that, while the bar is being heated up in a furnace of a given temperature, the temperature difference between center and surface of bar is approximately proportional to the diameter of the bar, for any one surface temperature. Let, for instance, a 1-inch diameter bar be heated in a 3,000 degrees F. furnace; then the center will have a temperature of 1,520 degrees F. when the surface has reached 1,620 degrees F., the temperature difference being read from Fig. 200 as 100 degrees F. In a 4-inch bar diameter, this temperature difference would be 400 degrees F., and in a 16-inch diameter ingot, it would be approximately 1,600 degrees F. In other words, while the surface has reached a temperature of 1,620 degrees F., the center is just beginning to warm up the least bit. And if the ingot were big enough, the outside might be melting before the temperature of the center had risen appreciably. These latter cases are, of course, entirely hypothetical, because no sane furnace man will subject large masses of steel to such temperature differences, except for the purpose of remelting the steel in the open hearth furnace, but the figures serve quite well for illustration of the principle. It is evi-

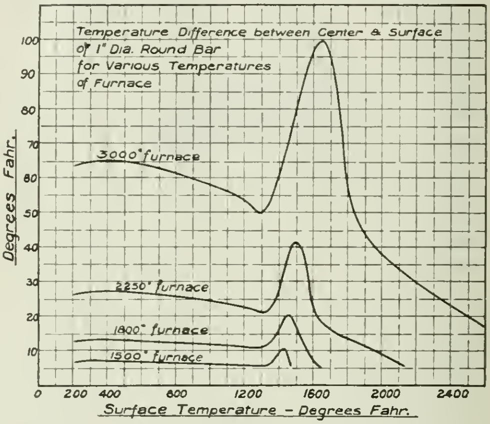

Fig. 200.

dent that in heating copper or aluminum, we cannot encounter such large temperature differences, first, because the thermal conductivity is higher, and second, because there are no recalescence points. These facts are illustrated by the thumb rule that, in a given furnace, we can heat 2½ times as much weight in copper billets as we can heat steel billets in a given time.

From the foregoing figures it follows that it is quite possible, in a sufficiently large furnace, to heat steel bars which are placed some distance apart, at the rate of three minutes per inch diameter. In practice this rate is not reached, because it is preferred to put more bars into the furnace and to heat each of them more slowly. By this method the total quantity of steel heated in unit time remains the same, while the heating time of each bar is increased to 8 or 10 minutes per inch diameter. In the heating of large ingots, the heating time varies from 18 to 35 minutes per inch diameter for well known reasons, see part II.

The curves of Figs. 199, 200 and 201 hold for round bars which are exposed to the heat all around. Corresponding curves may be derived for all other shapes, such as spheres, plates heated from the top only or heated top and bottom, etc. While this work is not overly difficult, it is most certainly tedious and time consuming. Until some one is too willing to pay for a more thorough investigation, the following approximation may be useful. Referring to Fig. 199, it can be stated that a sphere will reach a given surface temperature in about two-thirds of the time which is required to bring a cylinder to the same surface temperature. It may also be stated that a plate heated from both sides takes twice, and a plate heated from one side only takes 3½ to 4 times as long as a round bar of the same thickness, to reach a given surface temperature, with a given, constant furnace temperature.

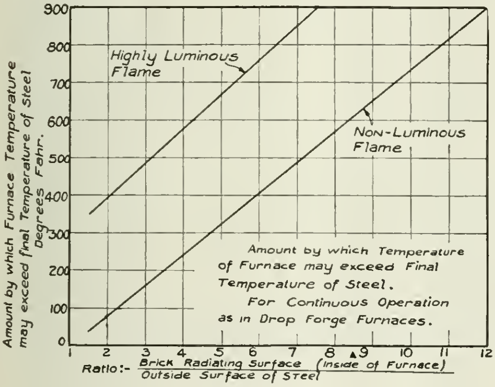

Fig. 201.

For finding the temperature difference between top and bottom of plate, the following reasoning may be used. A 1-inch plate heated from one side only corresponds to a 1¾ to 2-inch plate heated from both sides. Also, for a given furnace temperature and luminosity of flame (that is, for heating times as given above) temperature difference between surface and center is the same for a sphere, a cylinder or a flat plate heated on both sides, if they all have the thickness. A flat plate heated on one side only will have about 1.8 times the temperature difference of a plate heated on both sides. Attention is again called to the statement previously made, that these values are averages and approximations only.

The last chapter, which is now to follow, consists in a critical comparison of various types of furnaces. The answer to the question "Which is the best type of furnace?" can easily be given in general terms, such as: "That furnace-type which will give the most uniformly heated produce for the least money, in the long run". But the answer is much more difficult in a specific case, unless all of the surrounding details are known. The latter include quantity and shape of material to be heated, temperature conditions (degree and uniformity), fuels available, heating program (continuous or intermittent), materials handling facilities, relative cost of fuel and labor, and available space.

As an illustration of these statements we may use the fact that it is impossible to compare a furnace for heating heavy forgings to a furnace for annealing small steel balls.

Since comparison of furnaces for all possible uses is impossible, it is advisable to pick out a few representative groups of furnaces and to compare furnaces with each group. Applying the same general principles, the comparison of other groups will then be a comparatively easy matter.

As a first group, we may select the types of furnaces which are used for heating heavy forging ingots. This comparison will be given in the next installment.

INTERESTING ENGLISH COMMENT ON WELDING.

Recent favorable comment on welding by the Engineer, England's ultra-conservative engineering journal, are of special interest to American manufacturers at this time, when there is so marked a tendency in this country to adopt this process of jointing structures. The oxy-acetylene industry is much older in Great Britain than here, and it is reassuring to observe that welding applications in England coincides with advanced American practice.

"There can be no doubt about the attractiveness of welding as a means of making joints in most metal structures," says the Engineer. "Its advantages are so obvious and appear to be so great. First and foremost is the advantage of cheapness and convenience. Welding can be carried out not only with much less labor, but with much greater speed and convenience than by the old method of making joints. By comparison, riveting, involving as it does, the drilling or punching of holes in accurately determined positions, followed by the insertion of the rivets themselves, is a clumsy and costly operation. From the point of view of the strength of the resulting joint, also, riveting is far from satisfactory. Only by great care in design and construction can a strength approaching as much as 70 per cent of the original bar be obtained, and in most jionts the strength is very much less. Further, there are many cases where broken parts can be rejoined by welding, while riveting is out of the question and other methods are impracticable. It is small wonder, then, that this method of jointing structures by autogenous fusion is finding ever wider and wider application."

Fuels—Their Utilization and Conservation

Better Fuel Conditions and Particularly Conservation Could Be Brought About by Educating Those Directly Responsible for the Consumption of Fuels.

By CHAS. LONGENECKER.

NAPOLEON once remarked, "God is on the side of the heaviest artillery". This expression in modern times might properly be paraphrased, "God is on the side of the greatest fuel resources". Had Napoleon made war in 1918 instead of in 1815, he probably would have given preference to fuel instead of artillery. Furthermore there can be no extensive artillery equipment unless there is the fuel necessary for forging the guns and auxiliaries. In modern warfare there must not only be a plentiful supply of fuel, but it must be of the right kind. The Navy of today burns oil; the airplanes gasoline; while the implements of war are mostly formed by power derived from coal burned under boilers. Never before was fire employed in battle, as a means of offense or defense, and on such an extensive scale, as was the case in 1914 to 1918. Without ample fuel supplies it is most apparent that war cannot be waged successfully, and this holds true as regards commercial supremacy.

England appreciated the truth of this statement, for we find in "Chemical Technology" (Groves & Thorpe) this expression made in 1879, "The wealth of this country (England) derived as it is chiefly from her success in manufacturers, depends in a great measure on the abundant supply of one of the richest sources of artificial heat lying buried in the earth, in her coal fields. Great Britain had small influence in the councils of Europe until these were discovered and turned to full account by the indomitable industry and enterprise of her inhabitants, and without so invaluable an accessory to the acquirement of wealth and power, her commercial fate and fame might soon have sunk to the level with those of the self insignificant State in Europe". The same is equally pertinent to the United States, for no one can deny that the prestige which we enjoy is mainly attributable to our enormous fuel supply. How long we can maintain our present standing as a commercial leader will be detremined by the duration of our coal and oil fields.

While these resources have been a wonderful blessing, viewed from another angle they have been a detriment to research work. They have taken away the incentive for scientific investigation due to their abundance and naturally low cost. Of all the advances made in fuel and heat utilization, only one invention is credited to America, and that is the method of producing water gas, which was brought out by Lowe in 1874. Germany and England have been the leaders in the production of improved means of saving fuel, but this country is at last awakening to the situation. The cheapness of fuel in the United States in past years is best appreciated by recalling that in 1898 a ton of anthracite coal cost $1.41 and a ton of bituminous coal cost only $.89 at the mines. Natural gas could be purchased for 13 cents a 1,000 cubic feet and fuel oil at 2½ cents a gallon. With such prices prevailing there surely was little need of conserving fuel if viewed strictly from a commercial standpoint. Any plan of conservation which is based on utilitarianism alone will never get very far. Not until a direct appeal is made to the cost sheet will any notable advance be made. The underlying law of "supply and demand" cannot be ignored and will absolutely control conservation. Whatever improved methods or processes for saving fuel are presented must show economies to justify the installation of the equipment necessary to carry out the process. With high fuel and labor cost there is an incentive to install equipment which does not obtain when such costs are low.

Many commendable suggestions looking to fuel conservation have been offered, but in most cases it will be many years before such suggestions can be practiced in a degree which will bring relief.

The electrification of the railroads is undoubtedly desirable, but this is out of the question at this time when the railroads are struggling to remain solvent.

Likewise the harnessing of our unemployed water power is of unquestionable value, but until financiers can see sure dividends from such undertakings it will be given little consideration. Again as fuel costs increase such projects will receive a greater impulse. but in any case the law of "supply and demand" remains absolute. In an investigation conducted by the Canadian Commission of Conservation for the Bankers Trust Company of New York, it is recorded that the United States has 30,000,000 hp derived from water power. Canada has 19,000,000. Per capita, Norway has .54 hp, Canada .26 and the United States .07.

Again it has been stated that our mining operations have been conducted along most uneconomical lines and should be changed in the interest of conservation. This accusation is based on fact and it would certainly be to the interest of the people if a decided change could be made. The mine operator would undoubtedly be glad to act on this suggestion if practicable, but he is governed by economic considerations and would soon be a bankrupt if he tried to follow these ideas. The consumer today specifies what grade of coal he desires. He places a top limit on the ash content and a bottom limit on the Btu content. This was not true during the war and for awhile thereafter, when any grade was gladly accepted, but now that those strenuous times are passes, the consumer can dictate. If one operator cannot meet the specifications another will, and the first operator will suffer a loss. Faced with these conditions it is impracticable to expect that low grade coal and coal hard to mine will be brought to the surface until there is a demand for it, and until it will pay to do so.

Many other ideas looking to conservation have been promulgated but these also will require years to put into effect. They all have features of merit and should be applied as soon as conditions warrant. We should put into use the machinery and equipment at hand and the larger and more pretentious schemes will come in their season. The law of "supply and demand" is at the root of all changes, and like the mills of the Gods they at times "grind slowly".

It is also only too apparent that the people must be awakened from the lethargy into which they have fallen. It takes an immense amount of propoganda to do this. It is well illustrated in the case of the failing natural gas supply in the city of Pittsburgh. The companies supplying gas have repeatedly impressed upon the people the fact that they must place less dependence on gas, but these warnings have apparently been little heeded. Recently the selling companies set aside a week during which gas conservation was urged. It is rather out of the usual to see the seller asking the buyer to buy less of his wares and it is also unusual to find the buyer in many cases refusing to do so.

It may then rightly be asked what can we do at present to bring about better conditions along the lines desired? The following suggestions are offered for consideration:

First—Educate those who are directly and indirectly responsible for the consumption of our fuels along lines of more efficient utilization. In Bulletin No. 3, issued by the Wickes Boiler Company, is this statement, "Over one quarter of the yearly coal bill depends directly on the skill of the fireman". Such being the case and with the knowledge that firemen are in most cases unskilled the loss can be appreciated. The fireman instead of being regarded more as a laborer should be elevated to the rank of skilled workman and paid according to the skill attained. He should be instructed and encouraged and given some incentive to advance. The incentive that makes the greatest appeal is a bonus in the pay envelope, which could be rated according to the saving in fuel effected.

Second—Equip our boiler houses with instruments whereby the attendants may know at all times just what conditions exist in the furnaces. These instruments would pay for themselves in a short time. Where recording instruments are used the superintendent knows absolutely, if he has the correct instruments, how his fuel is being burned and can correct any laxness in his organization.

Third—Eliminate as far as possible all "hand firing" of furnaces and substitute mechanical means. This will apply both to boiler furnaces and to metallurgical furnaces. The equipment necessary to replace "hand firing" need not be elaborate and in many cases the equipment which serves one class of furnaces can serve another.

Fourth—See that the furnaces in which the fuel is being burned are of the correct design. There has been a marked advance towards increased furnace efficiency, and furnaces which were formerly satisfactory have been replaced by many superior types.

One of the controlling factors in any system of better fuel utilization is what may be termed "location. That is the location of the plant in which are the furnaces in question. This is well illustrated in a plant recently visited. Here the mine from which the company secured its coal was within 100 feet of the plant and the total cost of coal delivered at the furnace was $2.55. With such low priced fuel there was no want for fuel saving devices nor was the efficiency of the furnaces of great import. The conditions which obtain in this plant are entirely different from those in a plant, say in Boston, where the fuel cost may be five times as great. Again the Boston plant may be able to secure Texas or Mexican oil at a more favorable price than coal which adds another variable. In any consideration of fuel "location" is a determining factor in many ways. The "zoning" system inaugurated during the war took cognizance of this fact, and coal shipments were regulated in accordance with the location of the mine and the point to which the coal was shipped. More attention should be paid to the development of methods whereby fuels such as lignite and peat could be successfully burned on an extensive scale. This would be of great value to plants whose location is near these fields. In certain districts there are immense beds of peat and lignite, but the factories and steam plants in these districts do not burn these fuels. Instead they import bituminous coal or oil which must be hauled long distances. In Minnesota a company has been formed to burn the peat, which is found in great quantities in that state. A plant has been placed in operation in Minneapolis for the preparation of the peat, which will be burned in the powdered form.

Many engineers have advocated gasifying coal in by-product ovens or by "low temperature" carbonization. Here of course the by-products are recovered and the coal nets a greater return both in heat value and in money return, but this must be practiced on a large scale to be commercially successful. The initial outlay is great, but where it is feasible, there is no question of the conservation effected. Local conditions determine the success of such a project. There must be a ready market for the gas, coke and by-products and not too keen competition from electrciity.

What has been said so far has been mostly in relation to coal. The fuel oil situaton has been one of a varying supply and a consequent varying price. There has been over production at times when the price per gallon has fallen to an extremely low figure, and at other times there has been an insufficient supply and the price high. Oil is the most popular fuel on account of the ease of control in burning and its cleanliness. Hence it has been used in preference to coal in many places where coal could have been burned as cheaply. The greatest waste of oil is in the fields where it is produced. Before sold as a fuel for furnaces the lighter oils should be removed and the residue only disposed of. More stringent laws would curb the greed of promoters and prevent the waste experienced at the present time.

One other feature should be mentioned in considering any question with regard to conserving our fuels and that is the quantity we export. To show the influence this exerts on certain localities one example copied from the "Gas Age" of August 10, 1920, will suffice. In a pamphlet presented to the governors of six New England states and bearing the title "Present Fuel Crisis in New England" it is stated that a certain gas company was compelled to pay $17 a ton for coal and thus the price of gas was increased .93 cents. "The report urges immediate action to prevent a shortage and blames much of the situation, on the eastern coast, upon excessive exports." The question thus presented is what effect exports will have on the home market. Excessive exports of coal or oil will naturally decrease the supply and increase prices. How far will the amount of coal exported counterbalance what conservation we may practice at home? The bituminous coal mined in the United States in 1920 was 556,563,000 tons. The quantity exported by vessel was 21,778,000 tons and by rail and vessel to Canada 5,931,418 tons, or a total of 27,709,418 tons. Thus it is seen that in 1920 we exported 5 per cent of the coal produced. The oil production was approximately 450,000,000 barrels, of 42 gallons each. The imports will run about 105,000,000 barrels, while the exports will be approximately 8,000,000 barrels, leaving a balance of 97,000,000 barrels credited to imports, practically all from Mexico.

A factor of growing importance and one which will eventually be a source of a very considerable oil supply are the shales of the western states. It is estimated that in Colorado alone it will be possible to secure 25,000,000,000 barrels of oil from these shales. This field has as yet to be developed, and the yield is problematical, and while there are great possibilities, it should not blind us to the need of conservation at present.

Whatever the fuel it must be first brought to the point of consumption and there utilized so that its history falls into two subdivisions. One is under the control of the mining engineer while the other is under the control of the engineer at the plant. The latter supervises its disposition when it is received. In transporting the fuel others have a work to perform, so that all must work together to secure the most beneficial results. If the fuel is for domestic use the public is most intimately concerned, so that whatever use it is put to there should be close coöperation. Where so many are concerned coöperation is absolutely vital if any great advance is to be made.

As it has been so aptly remarked "the way to resume is to resume" and likewise the way to conserve is to conserve. Therefore apply at this time the tools we have at hand and do all in our power to forge other tools of a more powerful nature as soon as conditions are favorable.

The industrial steam trade is the one greatest consumer of fuel followed closely by the railroads. With this in mind and appreciating that in promoting the conservation movement it must be done on a practical basis, the following from "Steam Power Plant Engineering", by G. F. Gebhardt, is of interest:

"The most efficient plant, thermally, in the conversion of energy from one form to another, is not necessarily the most economical commercially, since various items involved in effecting this conversion may more than offset the gain over a less efficient plant. There is no question as to the low operating cost of power generated by hydro-electric plants, but when the cost of transmission and the overhead charges are taken into consideration, the economy is not so evident, and may be completely neutralized. From a purely thermal standpoint the Diesel engine electric plant is superior to the best steam electric plant for power purposes, but the fuel item is only one of the many involved in the total cost. It is the commercial efficiency which enables the steam power plant, with its extravagant waste of fuel, to compete successfully with the gas producer, internal combustion engine and hydro-electric plant".

Development of the Steel Industry During the War in Germany

A General Review Showing the Various Improvements That Have Been Made in the Different Stages of Steel Manufacture in Germany During the Past Four Years.

By HUBERT HERMANNS.
Special Correspondent, Blast Furnace and Steel Plant.

PART II.

THE basic open hearth slag, which used to be a useless by-product in former years, has, at the present time become a useful fertilizer for the soil drained heavily during the last years, on account of its contents of phosphoric acid. The quantity of slag, obtained by the basic open hearth process, amounts to about 25 per cent of the quantity of liquid steel made, which is naturally a considerable quantity in a modern plant. In a plant of 2000 tons capacity in 24 hours it corresponds to about 500 tons of slag. This is due to the large quantity of limestone added to the bath in the converter, which amounts to between 12 and 14 per cent of the used liquid iron.

An average analysis of the basic slag is as follows:

	Per cent
SiO_2	7.00
P_2O_5	18.30
FeO_2	6.20
FeO	9.60
MnO	6.25
CaO	48.60
MgO	2.60

Slag of this composition is ground very finely and then used as a very active fertilizer on account of its easy assimilation to the soil. The machinery for grinding the slag has been improved considerably during the last years by making it automatic as much as possible. Besides, the detrimental influence of the phosphoric acid and of the dust upon the health of the working men has been reduced to a minimum by means of different types of dust catchers and other contrivances, which prevent, at the same time, a loss of the valuable dust.

One of the main auxiliaries of a German bessemer plant is the installation for making dolomite bricks for the lining of the converters. Such a plant is of utmost importance at the present time and its layout and location in regard to the main plant has a considerable influence on the efficient working of the whole steel plant. In former years any place was good enough, any location was suitable and in many cases, the machinery and apparatus required for the manufacture of the dolomite brick was not even brought under one roof, but was scattered around, thus necessitating the carrying back and forth of the material. Another point, which had seldom been taken care of, was the fire protection in the tar refinery.

Recently plants for making dolomite stones are built with a main view of avoiding unnecessary transportation and to use, as far as possible, mechanical conveyors for this purpose. An installation of a modern dolomite plant is shown in Fig. 8. It is located near the converter building in a separate building of about 140 feet length and about 50 feet width. The furnace for making the converter bottoms and the tar refining are outside of the main building, whereas the storage tanks for the raw tar and the refined tar are underground. The largest part of the building, which is spanned by an electrically driven traveling crane of 12 gross tons capacity is occupied by the machinery for preparing the basic raw material also for manufacturing the bricks and bottoms. The tamping of the bottoms is still mostly done by means of the well known Kersen bottom tamping machine. The air pipes in the bottoms are made with steel needles attached to a plate. Tamping of a bottom with 205 wind pipes requires four to five hours.

In a separate room we find, besides the pumps for the brick press, three calcining furnaces and two bell grinders for crushing the calcined dolomite. The calcining furnaces are built like cupolas of about 7½ to 10 feet ID, with the tuyeres about 6 or 6½ feet above the floor. The coke consumption amounts to about 20 to 30 per cent of the amount of raw dolomite charged. The capacity of every furnace is approximately 15 tons of calcined dolomite in 24 hours.

The furnaces for burning the converter bottoms are built somewhat similar to kilns. They have two or three grates for direct firing on each side, allowing the simultaneous charging of between four and six bottoms in every furnace. The time required is about 36 hours, to which must be added two days for cooling of the finished bottoms.

If small space only is available it is advisable to distribute the machinery for the dolomite plant over two floors. This can be done in such a way, that the first floor will be reserved for the bottom stamping machine and the calcining furnaces, whereas the apparatus for preparing the basic raw material and the brick press can be erected on the second floor. In this case the calcined dolomite will be lifted by a conveyor on the outside of the building and discharged into the grinders which are located on balcony between first and second floor. From the grinders, the ground dolomite is taken by means of a vertical bucket conveyor into bins, from where it drops over shakers into the grinding plates of the crushers.

The transportation of the steel ladles is done, in

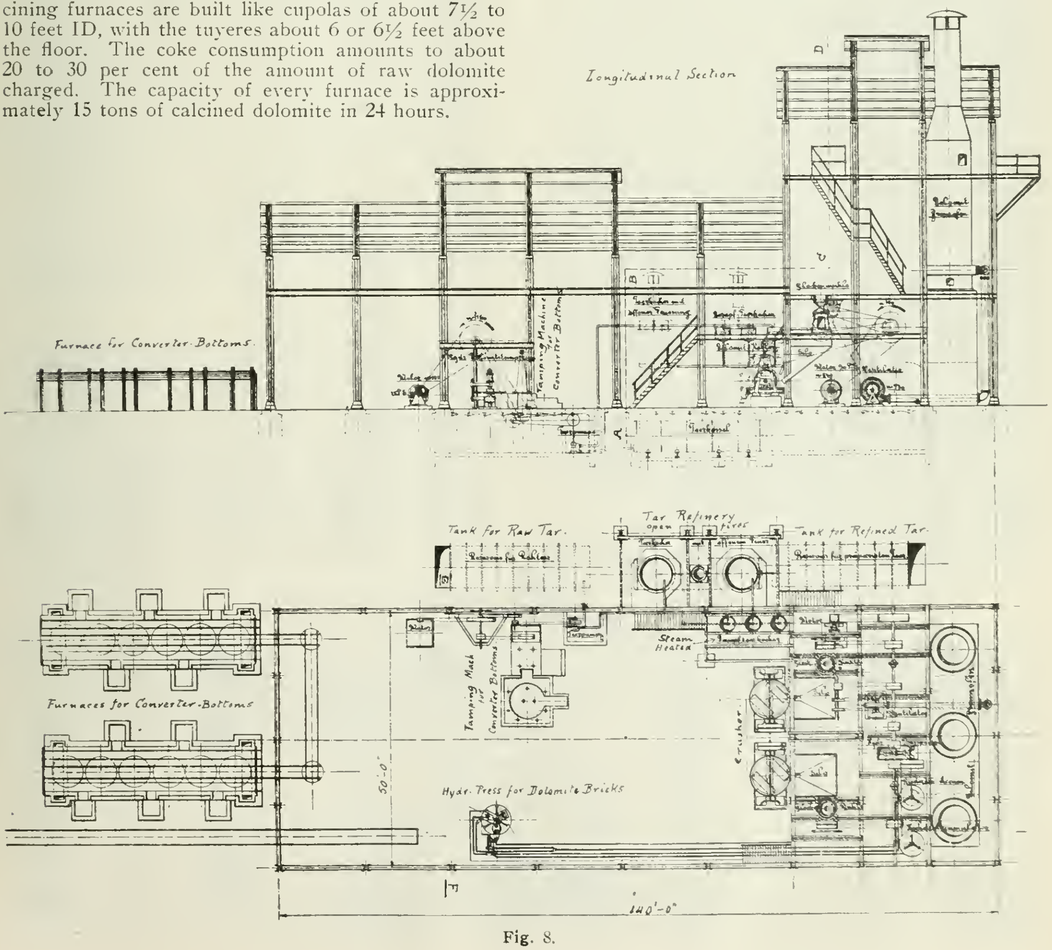
Longitudinal Section
Furnace for Converter Bottoms
Tamping Machine for Converter Bottoms
Tank for Raw Tar
Tar Refinery open fires
Tank for Refined Tar
Steam Heated
Furnaces for Converter-Bottoms
Tamping Mach. for Converter Bottoms
Crusher
Hydr. Press for Dolomite Bricks
50'-0"
140'-0"

Fig. 8.

converter plants, by means of cars, which had formerly been driven by steam, but which, since the beginning of the century, have been changed to a purely electric drive. This causes a very unfavorable load on the lifting motor, because the latter has to lift and to accelerate not only the weight of the ladle, but also that of the upper part of the car with all the gear trains, motors and the heavy balance weight. For this reason, the lifting motors get out of order easily, which should be avoided under all circumstances. It has therefore been found to be of advantage, to restrict the electric drive to the traveling, turning and tilting motions, whereas the lifting of the ladle in the vertical direction is done by means of hydraulic pressure.

The transportation of electric energy into hydraulic energy means, of course, a loss in efficiency, which will still be increased by unavoidable leaks in the lines and in the stuffing boxes of the operating cylinders. The advantage, on the other hand, lies in the fact, that it is possible to obtain, by means of hydraulic energy, a smooth motion free of stocks. The operating cylinder fits over the central column, which acts as a plunger and the diameter of which depends on the bending moment caused by the ladle and the counter weight as well as on the total weight of the structure and in the hydraulic pressure. The water enters the upper part of the operating cylinder and with a pressure of between 575 and 650 pounds per square inch. The waste water leaking out through the packing of the plunger is collected by a stuffing box at the lower end of the cylinder and is returned to the hydraulic tank. The working velocities are 4½ feet per minute for lifting and 20 feet per minute for traveling.

Basic Open Hearth Plants.

The great advantage, undoubtedly connected with the Siemens-Marten tilting furnace, have increased in the last years, chiefly under the influence of the war, the installations of furnaces of this type in German plants. The advantages of such furnaces are not so much due to an improvement in the quality of the steel, but to the possibility of increased production. Fig. 9 illustrates a section through a plant with a tilting furnace of 80 tons capacity. This plant is provided with as many labor saving devices as possible and can be considered as a model plant. The furnace is located in the center of the building, which allows the use of the same crane for charging and tapping.

A few remarkable improvements have been made in connection with the operation of the furnaces. It is well known that the "boiling period" forms the most important part of the melting process in regard to chemical reactions. During this period, the carbon in the bath is oxidized to carbon monoxide. The rising of carbon monoxide bubbler causes the "boiling", through which all parts of the bath becomes decarbonized more or less completely. The completeness of the reaction depends upon the temperature and upon the amount of carbon present. The more favorable the conditions are made for the reaction, the smaller a percentage of pig iron, under otherwise equal conditions, can be applied with the scrap and the shorter will be the time of the heat.

The oxygen required for the oxidation of the carbon in a standard pig iron scrap charge is furnished by the excess air, used for the combustion of the fuel gas. The usual arrangement of the parts of an open hearth furnace is such, that the air travels through the hearth above the gases. Since the boiling period starts immediately after the melting down of the bath, and since the reaction is carried through the quicker, the hotter the temperature of the bath, it is evident, that a large excess of air is detrimental to an increase of the temperature of the bath, because it lowers the flame temperature. Conditions, however, can be reversed by means of a new reversing arrangement, which permits a changing of the gas and air currents during the boiling period in such a way, that the gas current flows along the crown of the furnace, whereas the air current is directed towards the bath. During the rest of the working period the usual method prevails. The new reversing valve consists of a bell, which revolves with a circular seat on a stationary plate, which contains the openings for the chambers and the stack. The openings are arranged in such a way that the air and gas flues are located opposite to each other. This is also the case with the openings for the stack connections.

The fuel conditions in Germany have forced to a large degree, the replacement of bituminous coal by brown coal, even for gasification. The brown coals, containing around 40 to 60 per cent of moisture, are briquetted and have a heating value of 8000 to 9000 btu per pound, against 10,800 to 12,500 btu per pound, for bituminous coal. The briquets must be strong enough to withstand crushing, in order to insure normal gasification in the producer. In order to prevent excessive clinkering, brown coal briquets require the addition of steam for gasification just as well as ordi-

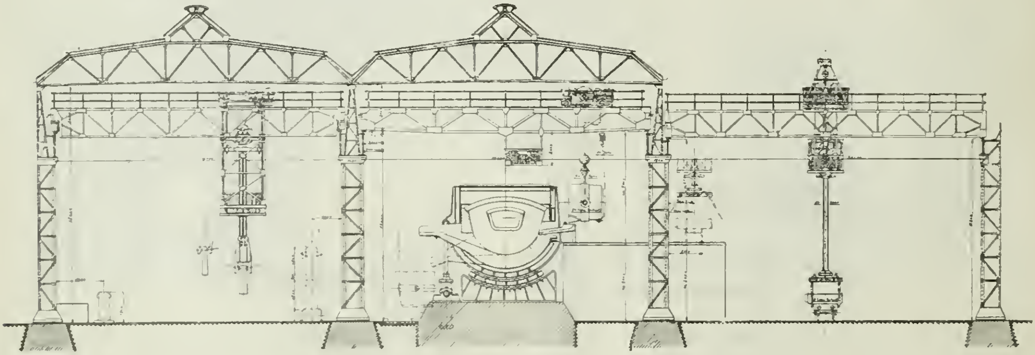

Fig. 9.

nary coal. The hydrogen, resulting from the dissociation of the steam, has apparently no detrimental influence upon the quality of the molten steel. There was, however, up to the present, not very much chance to make any investigations in connection with this question on account of the short time available.

Very favorable working conditions have been obtained in Germany in open hearth furnaces by the application of a mixture of coke oven gas and blast furnace gas and with cold coke oven gas alone. A large number of plants have turned, for want of other fuels, to the application of cold coke oven gas, chiefly in order to make use of the much higher heating value of coke oven gas, as compared with that of producer gas.

Coke oven gas, when first applied, was burned in furnaces, which were built originally for producer gas, but it was soon found that the furnace did not give the expected results. Coke oven gas requires, for a complete combustion, a long hearth, because the velocity, with which it leaves the ports, is high, besides, the thin stream of gas must be heated to give a larger volume in order to insure a complete gas-air mixture. Where the hearth is too short and cannot be lengthened out on account of local conditions, difficulties will arise, because part of the gas will only burn in the down-takes, thus causing overheating of the chambers. After the furnace is shut down, the checker brick must then be renewed. Careful supervision, however, will reduce those difficulties to a certain extent.

With 100-ton furnaces conditions were more favorable, because the hearth was long enough and the temperature in the chambers remained normal. No excessive repairs were necessary on the crowns of the furnace.

Economical working conditions depend upon the heating value of the gas. With gas of 480 to 500 btu per cubic foot, the gas consumption amounted to approximately 10,600 cubic feet per long ton; the time for the heat in a 30-ton furnace was five to six hours and in a 100-ton furnace, nine hours. When the heating value of the gas drops to about 450 btu per cubic foot, the time for the heat increases considerably. A heating value of 425 btu per cubic foot made the working with the 30-ton furnace uneconomical. A 100-ton furnace can be kept running with such a gas, but only with difficulty. It has been tried lately to get around these conditions by preheating or enriching the coke oven gas, but, so far, results of these tests have not been published.

As far as the practical results of the application of coke oven gas are concerned, it has been found, that the average life of a furnace was 3½ months, giving 350 heats of 30.6 tons each, or a total of 10,725 tons, corresponding to four heats in 24 hours. 100-ton furnaces lasted, in an average, for 6½ months, giving 318 heats of 97.3 tons each. After this period, furnace and air ducts had to be rebuilt. The checker bricks usually were renewed also. These furnaces were charged with liquid pig iron.

For metallurgical operation coke oven gas has the advantage, that it is moisture free inconnection with a low percentage of sulphur. The high percentage of hydrogen favors the creation of a reducing atmosphere above the bath. The consumption of manganese is, as a rule, lower, than when producer gas is used; besides there is a considerable saving in refractories, wages and steam. As coke oven gas burns with a non-luminous flame, the furnace operators have to get used to the new fuel. At first, they mostly give the furnaces too much gas, which causes the chambers to run hot. But as soon as the melters are familiar with the non-luminous flame, they prefer the coke oven gas to the producer gas.

In other plants, successful attempts have been made to apply a mixed gas, composed of blast furnace gas and coke oven gas. In order to obtain a complete mixture of the two constituents, special mixing apparatus were designed. One cubic foot of the mixed gas weighs about .06 pounds, and the volume of 1 pound is about 16 2/3 cubic feet. The heating value of 1 cubic foot of the gas is 238 btu, that of 1 pound approximately 4000 btu. The gas was preheated to 2075 degrees F. and it was mostly used for the manufacture of quality steel, i. e., of high carbon steels and alloy spinal steels. The procedure is as follows: At first melting is done with an oxidizing atmosphere, then, the blast furnace gas is throttled and an atmosphere, as poor in oxygen as possible, is generated over the bath by means of the rich gas. At the same time the bath is heated to such a temperature, that a slag is formed of such high basicity and chemical activity that the phosphorus and the sulphur go into the slag and are removed almost to the last particle, where the slag is tapped, without decreasing the contents of carbon in the bath or without causing the destruction of eventual addition of chrome, nickel or tungsten, etc.

The furnaces in question were tilting furnaces, 33 feet long inside, tilted electrically. The roofs last for an average of 380 heats. A thorough repair of the furnace takes about three or four days. Removal of the ports makes all parts easily accessible. After the ports have been removed, the hearth is out of a direct connection with the chambers, thus enabling a cooling of the furnace in a very short time, after the old crown is broken down, and rebuilding can be started after a lapse of about three hours. The checker bricks last for several years, because the mixed gas is very clean.

In general, it can be said, that the German steel plants strive to utilize high grade gases for melting purposes, using the low grade gases for auxiliaries. Thus some plants use blast furnace gas in their coke ovens, using the coke oven gas for melting steel. Producer gas for the coke ovens can also be made from the coke breeze applying for this purpose a slagging type of producer. A more indirect way is to heat the cowpers with gas from slagging type producers, use the thus liberated blast furnace gas for the coke ovens and melt the steel with the coke oven gas.

Iron and Steel Foundry.

During the last years the German iron and steel foundries had to increase production by all available means, in order to comply with the large demands of the war. There was for this reason, no time left to introduce fundamental improvements into the practice. The trend of the operation was chiefly directed toward the installation of labor saving devices and machinery, in order to increase production and reduce wages. Besides, during the last years of the war and afterwards, the desire of using scrap in every form became more and more evident, and, for many foundries, this was simply a question of life or death. Lack of pig iron and steel scrap, as well as lack of fuel forced the manufacturers to reclaim the iron scrap and to utilize the heat of the fuel as much as possible.

The necessity to save labor and make it free for war service forced, in many plants, the installation of extended transporting and conveying appliances.. Sand was also more and more handled by means of machinery, but this part of the foundry work had already been considerably improved before the war.

Much trouble was encountered on account of the low grade of the foundry coke, caused by an increase in its contents of ashes and sulphur. The castings, therefore, also contained a high percentage of sulphur, which reacted, in some cases, .15 or even .2 per cent. This condition was also made possible, because, for want of pig iron, plenty of low grade scrap had to be used. Besides there was no pig with high enough percentage of manganese, thus causing an incomplete desulphuring of the iron in the cupola.

Low contents of silicon caused other troubles when casting. The castings, in many cases, showed great hardness, and an inclination for excessive internal stresses. These troubles were only increased by the use of the scrap iron. An addition of pig iron high in silicon removed the difficulties at least partly. The American foundryman can hardly make himself a picture of the difficulties, under which the German foundryman was forced to work. Those foundries, which had laboratories of their own, were, of course, not in as bad condition as the many small plants, which only worked according to old practice.

A large increase was made in the output of steel castings. This increase was mainly accomplished in the electric furnaces. The production of high grade steel increased from 107,916 tons in 1908 to 349,484 tons in 1917. The table below shows the increase in output for crucible steel and for electric steel:

	Crucible		Electro Steel		Total
Year	Tons	Per cent	Tons	Per cent	Tons
1908	88,183	81.9	19,536	18.1	107,916
1914	95,096	51.6	89,336	48.4	184,432
1915	100,578	43.3	131,579	56.7	232,157
1916	110,472	38.2	178,585	61.8	289,057
1917	129,784	37.2	219,700	62.8	349,484

This table shows, that the ratio of the production of crucible steel and electro steel changed more and more in favor of the latter. About one-third of the quantities given were made in the induction furnace, while the rest was made in the arc furnace. The electro furnace proper has not been changed to any extent in Germany during the war. Those types of direct and indirect arc furnaces and induction furnaces were applied, which had already given satisfactory results before the war. At that time, there were in Germany about 20 foundries which had electric melting furnaces, at present, this number is doubled. The average capacity of the furnaces built during the war, is 6.7 tons.

The output of acid-steel castings was, in 1917, with 828,837 tons, nearly seven times as large as in 1913, and that of basic-steel castings with 626,237 tons, about 1.5 times as large as in 1913. The small converter plants, on the other hand, did not develop in a similar scale, mainly for the reason, that they require high grade pig iron, which could only be obtained in limited quantities.

(To be concluded)

Accidents in the By-Product Coke Ovens

How Safety Work Is Being Carried on in the By-Product Coke Oven Industry—Charts Showing Comparison of Accidents as They Occur in the Industry.

By FRANK H. ROWE,
Safety Inspector, Portsmouth Solvay Coke Company.

IN the solving of industrial problems of the day it is necessary that all minds intelligently coöperate with each other so that the desired end might be obtained. The modern executive has but to be shown the need of a thing in order to convince him of its necessity. This article will endeavor to show the need of better accident prevention work on by-product coke ovens.

The Aim of Safety Work.

The wonderful success of the safety movement is due to one thing: It has been demonstrated that the right kind of safety work saves human lives and usefulness. Understand the right kind and not the bottle fed kind. Not only has it been demonstrated that safety saves human lives and usefulness but it actually increases production. Educate a man to save fingers, arms, limbs and lives and you educate that man to save material, time and effort. All safe plants are efficient and all efficient organizations are safe for the one and only reason that it isn't efficiency or safety when you cut off a man's arm or leg.

The Coke Oven Industry.

We are chiefly concerned in this article about accident prevention work and its results on by-product coke ovens. The coke oven industry of this country is divided into two sections, namely, the bee-hive coke ovens and the by-product coke ovens. Inasmuch as we are treating the subject from the by-product standpoint a few general facts may not be amiss. The first by-product ovens were brought to this country in the year 1892 by the Solvay Process Company. They consisted of a battery of 12 ovens, and are still in use at Syracuse, N. Y. From this small beginning the industry has grown to the point where it now consists of 8,904 ovens, employing at the close of 1919, 15,408 men. In studying the accompanying charts it might be well to remember that the bee-hive ovens employed more men up until 1919, than did the by-product ovens.

Like all modern industries the electric motor has supplanted the use of man power as far as it is possible to do so, and in doing so it has increased the accident rate of the industry.

Fig. 1 graphically illustrates the number of men injured per 1,000-300 day workers in the by-product coke oven industry. Starting in 1915 with 140 employes injured for every 1,000-300 day workers the rate rose steadily until the peak came in 1917, with 300.6 employes injured per 1,000-300 day workers. The by-product coke ovens suffered worse from accidents during the war than the great iron and steel industry did. The frequency rate was higher and held up longer than in the other important industries. It is gratifying however to see the rate decreasing to the old standard of a pre-war basis. But even the rate of 140 employes injured per 1,000-300 day workers is too much for the industry to hold.

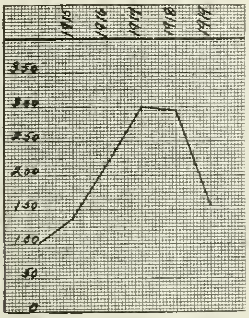

Fig. 1—Number of the injured per 1,000-300 day workers on by-product coke ovens for the years 1915-19.

A look at Table 1 will show the results of a comparison between the by-product coke ovens and the iron and steel industry.

Table 1—Total Accidents per 1,000-300 Day Workers.

	1915	1916	1917	1918
By-product coke oven industry	140	217.09	300.6	296.06
Iron and steel industry	124.5	133.2	103.4	.....

We have believed the steel mills to be the more dangerous places to work and yet the records do not prove out that fact. Either the by-product coke oven industry is a hazardous industry or there is a lack of organization within the industry to adequately take care of this phase of the work. Note the ratio of three to one during the year of 1917 for the two industries. Frankly, from a machine standpoint the by-product coke ovens are not to be compared to the mills of the iron and steel industry as to accident hazards. The only answer is that the safety movement hasn't gathered momentum enough to push through anything that looks like a real solution of the problem. Safety departments are still considered a necessary evil to be dealt with, as each individual seems fit to deal with them. This condition is being rapidly overcome, but we still find traces of the old way of doing things. Make up your mind to one thing, you are either going to have a safety department that functions or one just because you think it is necessary. Makes no difference what kind it is, it will not take the men who work for you very long to find out what kind of safety you are getting out—real safety or sham safety.

The acme of success in safety is the achieving of that for which we strive. The safety movement having been organized to save human life, its success must necessarily be based on what it has done along these lines. Chart No. 3 illustrates what happened during the years 1915-17 in the by-product ovens, as compared to the iron and steel industry.

Here again we have the 3 to 1 ratio that we had in the previous sketch. The rate has decreased to some extent since then to be sure, but as in the case of all accidents the rate is too high for the hazards that the industry carries. It only goes to show the need of increased efficiency in the application of safety education.

Table 2—Accidents for All Coke Ovens. 1915-19 Five Year Period.

Causes	Killed No.	Killed % of total	Injuries No.	Injuries % of total
Cars, larries and motors	81	24.54	2359	8.19
Railroad cars and locomotives	60	18.18	1116	3.87
Coke drawing machines	16	4.85	952	3.30
Electricity	16	4.85	224	.78
Falls of persons	40	12.12	3770	13.09
Hand tools	2	.61	3259	11.31
Suffocation from gases	13	3.94	196	.68
Burns	26	7.88	3830	13.29
Falling objects	6	1.82	508	1.76
Gas explosions	2	.61	144	.50
Other causes	68	20.60	12556	43.23
Total	330	100	28814	100

The factors that enter into these causes of accidents are not so much the lack of safe guards, but the lack of the use of ordinary precautions in the operation of the prime movers in these hazards. It is not the lack of safe guards but the lack of safety instruction that causes the vast majority of these accidents. There are, of course, some causes that can be eradicated through better guarding. For instance, take the cause of "Falls of Persons"; the decreasing of accidents from this source means that all runways must have the proper hand-railing, that all ladders must be equipped with non-slipping shoes and that all scaffolds must be properly equipped with safety devices.

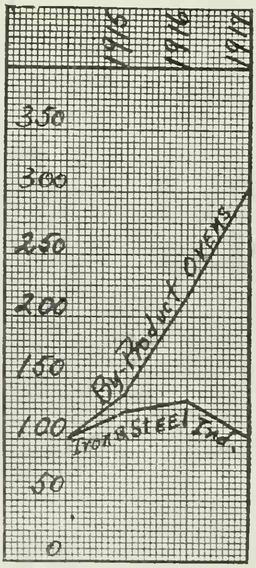

Fig. 2—Comparison of the number of employes injured per 1,000-300 day workers for the two industries, by-product coke ovens and the iron and steel industry.

The subject of accidents occuring from "railroad cars and locomotives" can be taken care of through

(Continued on page 187)

Constructing a Heat Treating Department

A Brief Outline of a Few of the Important Items That Constitute an Efficient Plant for the Heat Treatment of Steel.

By L. C. DUNN,
Montgomery Chemical Company, Detroit.

IF ANY kind of a manufacturing plant is to make a profit, the closest attention must be paid to the details of its design and construction. Lack of attention to the apparently trivial details will often cut heavily into the contemplated profits. In this article we will try to set forth some of the points that should be considered in planning and building a heat treating department. We will endeavor to study the question thoroughly. This will of course necessitate covering many points which are obvious, but which, if not considered, may make it necessary at a later date, to radically change the installation and add greatly to the expense.

The Montgomery Chemical Works built a commercial heat treating department in Detroit. Competition is very keen in this city because most of the automobile manufacturers have very efficient plants of of their own. Costs are well known and, on account of systems of handling and time study, are extremely low. The quality of the work demanded by this branch of industry is exceptionally high. It can be readily seen that the problem presented to the Montgomery Chemical Works was to build a plant that would be able to turn out quality work in large quantities in the shortest possible time, and at a price close to the customers own figure for doing the same work; and at the same time make a profit. This meant concentrated study, and resulted in a plant having several unique and efficient departures from general practice. If every plant construction engineer was given a similar statement of requirements much could be added to the efficiency of his completed plant.

We do not wish this article to be accepted as a description of any one establishment, but in it we hope to embody a set of specifications for a good heat treating plant, with notes on how to attack the various problems, and to outline some of the reasons for doing or not doing certain things in a particular way. When we lack better examples we will refer to plans, sketches or photographs from the plant mentioned above.

It might be well to mention, before proceding further, a problem presented to the commercial heat treating concern which does not confront the average manufacturer; but should, however, have his attention. The manufacturer usually has a limited number of different parts to treat. and when he builds his department, he does it with these in mind. We might say he tools up for these particular jobs, selecting his furnaces, tanks and all other equipment for them alone. Later changes in design, or additions to his line of manufacture obsolete his equipment or at least require expensive alterations. A commercial plant must, and any other plant can be made flexible, fitted to handle any class of work, at very little extra initial outlay.

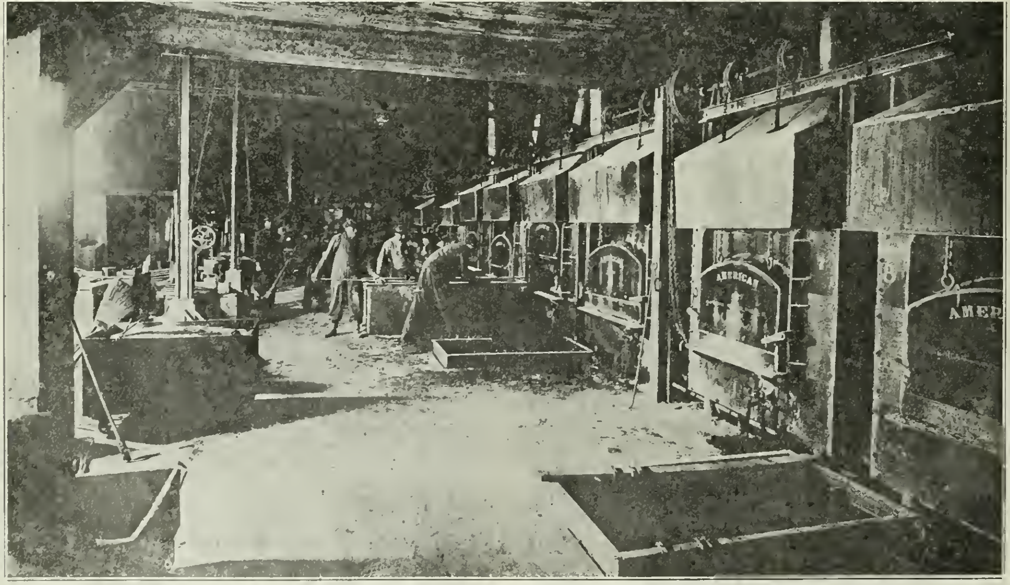

Fig. 1—Battery of heat treating furnaces. Note tank arrangement and trenches under the furnaces.

Another point before we go into details of construction. Design the plant, building, machinery and every thing else on a scale that will take care of requirements 5 or 10 years in the future, then cut off from the finished plan the section of the building not required for immediate production needs. Too often have we seen one unit after another added to an original installation that was built without any regard for the future. The results are always the same. Furnaces must be placed in bad positions and machinery in undesirable locations. More piping and valves are installed than are necessary if a definite plan is followed. Floors have to be torn up and relaid, and aisles are often blocked. Men are forced to work closer to the hot furnaces than necessary and general confusion ensues.

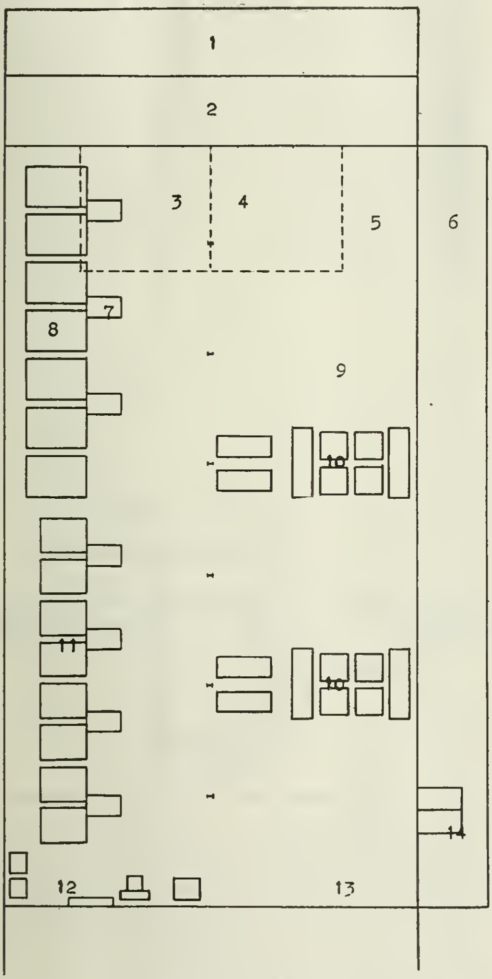

Fig. 2—Plan of department.

1. Covered truck drive. 2. Covered loading and unloading platform. 3. Upstairs toilet. 4. Upstairs shop office and pyrometer control. 5. Forging cooling floor. 6. Forging loading dock. 7. Tanks. 8. Heat treating furnaces. 9. Inspection. 10. Lead pots, cyanide and salts. 11. Carburizing furnaces. 12. Machinery and switchboard. 13. Compound storage and packing. 14. Pot cooling floor and dumping pits.

It is advisable to place the electric switch board, gauges, pumps, blowers, motors and all other machinery at one end of the department, allowing sufficient room for future expansion; and if the expansion is seen to be in the near future, purchasing all machinery large enough to provide for the entire contemplated furnace equipment. This plan not only places all the units requiring constant attention where they will be readily accessible to the man immediately in charge of the machinery, but also makes convenient a minute daily inspection by the foreman or superintendent, insuring the plant against many needless shutdowns, due to lack of proper care. A still more efficient grouping of the machinery may be effected in a basement if it can be constructed under one end of the building; and if this can be extended under the entire department it will provide room for supplies and allow the valuable floor space above to be used exclusively for the heat treating operations. We have seen machinery scattered all over a department; in pits, hung from the roof girders, and in different parts of the room. When production increased and the department was enlarged, more machinery was installed and more pipe lines connected until it was very confusing to trace the water, gas, fuel oil, quenching oil, and electric lines, and extremely difficult to know which valve or switch to throw in an emergency. Grouping the machinery at one end of the plant simplifies this, as a minimum amount of piping is required, and but few valves needed. When more furnaces are installed, plugs are removed from the ends of the existing lines, and the pipes lengthened without removing any part of the original installation or making any alterations in it. At this point we wish to call attention to the fact that if tees are used instead of couplings in the

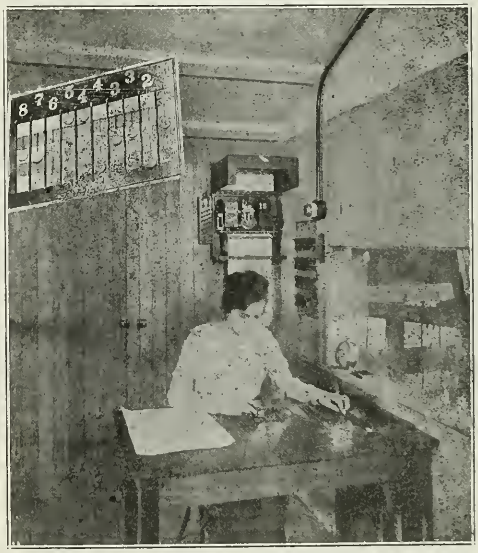

Fig. 3—Temperature control table. Note signal board outside of window. Better view of signal board has been inserted in upper lefthand corner of this cut.

pipe lines, also more unions than would ordinarily seem reasonable, the additional cost is insignificant compared with the time saved in cleaning or repairing lines, or making some unforseen future addition.

Some of the units should be installed in duplicate. If the department is working on a 24-hour basis, and all of the furnaces are full of work, it is very costly to have a motor blower, or oil pump refuse to function properly. During the war a very large automobile factory, working on Liberty motors, ruined in succession three Liberty engines installed as temporary substitutes for a burned out high speed electric motor, before the necessary repairs on the electric motor could be completed. A shut down covering this period would have been extremely expensive as it would have cut off all assembly, testing and shipping for two weeks. The price of these motors, the cost of tearing them out and replacing them, the expense of the men constantly watching the delicate engines, the loss in production in the entire department and the wages of over 100 men idle, not only while the original motor was being removed and replaced, but also while each of the three Liberties was being installed and torn out, would have purchased several new blowers, if not duplicate equipment for the entire department. In addition to this, quite a bit of work in process in the department would not pass inspection, accounted for by uneven heats on work that was in the furnaces during these frequent enforced breaks in the normal working conditions. The cost of duplicate machinery is often a very considerable item, but even if it is not used this cost can be considered insurance; insurance against a costly break in production.

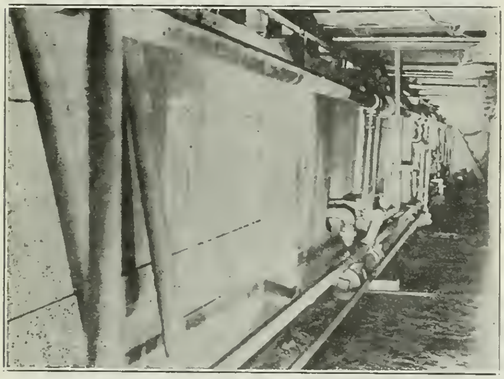

Fig. 4—Trench under furnace carrying all pipe lines. Notice lines passing through wall to tanks.

Another point we must consider is that often during certain periods of the year the production demands are low, or possibly it is necessary to run only a very few parts on a Sunday or a holiday. To meet conditions of this kind it is advisable to have a small unit, say a large and small furnace and a lead pot, connected to a blower and oil pump only large enough to serve the necessary burners. This unit need not be separate from the rest of the units, but can have its own separate pipe lines that may be cut in or out of the large unit. By turning a few valves the small blower and pumps can be cut out, and the furnaces run from the larger machines.

After having determined the quantity of work to be processed, the size and type of furnaces required, the equipment needed to deliver oil, gas, air and water to the furnaces and tanks it is time to determine the size and shape of the building that will most efficiently house the outfit. If other buildings or a peculiarly shaped piece of property do not limit the shape and size of the building, the width should be determined by the way in which the furnaces are to be arranged. It has been found, from inspection of many of the most modern heat treating departments of the country, that a building 60 feet wide fulfills the average requirements; but furnace arrangement, the size of the heating units, and special conditions may make it advisable to use a much wider building. For general automobile manufacture and machine tool work a 60 foot building seems to work out to the best advantage, therefore we will consider a building this width for the remainder of the discussion. Needless to say, the fewer columns required the better for unobstructed work; but a row through the center of the building does not present any serious disadvantages, and avoids the necessity for expensive heavy roof trusses.

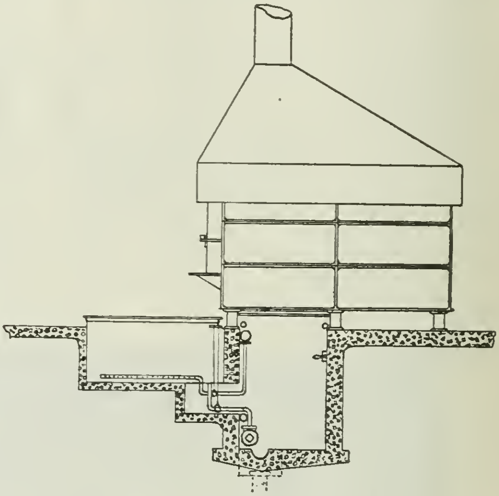

Fig. 5—Section through trench showing piping to tanks.

The material used in constructing the building is not of vital importance, but the construction must be fireproof, with the possible exception of the roof, where necessity may enforce economy. Good ventilation is an absolute necessity, therefore the monitor type of building is admirable, as it not only furnishes free circulation of air, but also considerable light. Fill the side wall with as many Tuscon windows and doors as is practical. The openings and the monitor will make working conditions satisfactory during the hot summer months, and the heat generated by the furnaces will keep the department comfortable in winter. The driveway should be at such an elevation level that an automobile truck body will be level with the floor of the receiving room. If a basement is constructed under the heat treating department considerable excavating can be avoided and the entire working floor built to this level; otherwise an inclined runway can be cut lowering the driveway to one of the doors. Loading to and from trucks on one level eliminates the needless expensive lifting of tons and tons of steel and supplies.

Having determined the size of the building, we now wish to place the equipment, and in doing so we must consider some points that will greatly aid to the efficiency of the department. We will first try to install each unit, with the idea of conserving floor space. We do not mean by this that furnaces should be placed with only a few inches between them, nor that the machinery should be crowded into a limited space. It is often desirable to replace a furnace or piece of machinery with a better type than is available when the department is built, therefore a reasonable margin should be allowed around each unit to permit a variation in size and shape of the unit replacing the old one. By conserving floor space we mean that by properly grouping the various classes of equipment, as will be explained later, certain floor areas will be reserved for the necessary equipment, and a maximum amount of efficient working space retained for the operators, and there will be left a minimum amount of waste room, which always acts as a catch-all for dirt and refuse. We must space the furnaces so men will not be working on one furnace and have another hot one behind them. Certain classes of work must be done in one part of the room and other unlike work in another. For instance all of the carburizing should be done in one group of furnaces, and these should be placed, not only near the space reserved for packing the boxes, but also near the cooling floor. Some units must be reserved for the finishing heats on the carburized work and others for the straight heat treatment of alloy steels; and a still further division should be made for the first, or high heat for quenching, and the lower heat for drawing. The object of these divisions is to facilitate routing the work through the department, to have no one class of work cross any unlike class, to eliminate unnecessary handling, and to insure a rapid movement through the plant. If we are to do heat treating work on alloy steels in considerable quantities it is advisable to have it unloaded on a large outside covered storage platform. Should this work constitute the largest proportion of the tonnage, place the high heat furnaces near the door. After quenching remove the steel from the tanks and pass it to the low heat drawing furnace, also close at hand, then to the cooling floor at the same end of the building, either inside or outside. On work of this class it is best to have the high and low heat furnaces in units of two, located side by side, quench from the high heat, remove the work from the tank and pass it directly into the low heat furnace. This eliminates one handling.

The inspection tables should be close to the cooling floor. After inspection, the parts can be placed on racks and the perfect work run out on the opposite end of the unloading platform, if space allows, or to another platform reserved for finished work alone; and the rejects can be returned to the high or low heat furnaces as dictated by the inspection readings. In a like manner the work to be carburized will pass directly from the unloading platform to the packing tables: to the furnaces; to the cooling platform; then to the high and low heat lead pots or finishing heat furnaces, reserved for this work alone; to polishing and inspection and then to re-operation, or loading platform as the case may be.

If possible to plan it successfully, not only should heat treating and carburizing operations not cross, but no one part of these two major divisions of the work should be allowed to cross any other part of that same operation.

From the foregoing data we find we have a number of things for which we will have to allow certain storage space, or furnace capacity. At this point we must figure about how much stock is liable to be piled on our loading platform ready for operations; minimum furnace capacity for the various operations; floor room for work that has passed through one or more of the various steps, but is not completed; space for drawing heat cooling floors, place for inspection benches; space for completed work ready to leave the department and also room for steel that would not pass inspection and must be re-processed.

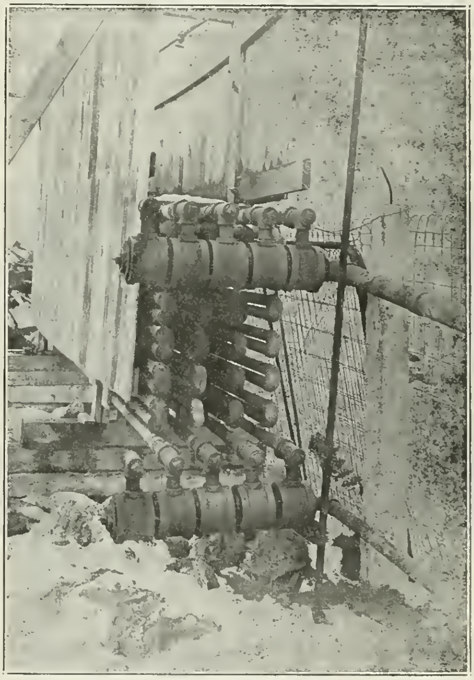

Fig. 6—Quenching oil cooling coil. Additional coils can be added when required.

We have all been in heat treating departments that gave us the impression that the equipment was thrown into it, and was piped up just where it landed. We have seen several such plants where it was thought it would be necessary to add more floor space to accomodate increased production, but where after the equipment was nearly all torn out, rearranged, reinstalled, and more added, there was still room for additional units. To avoid a condition of this kind is our object; and this object is best attained by first drawing a plan of the proposed building, say on a scale of one quarter of an inch to the foot. Next cut from card board, to exactly the same scale as the floor plan, pieces to represent the furnaces and machinery, selected as being best adapted to the work to be treated; and also pieces to represent the packing and inspection tables; hand truck platforms for raw, completed and semi-completed work, and for work to be re-processed. Also cut cardboard pieces to the same scale to represent the number of square feet of floor space required for drawing-heat, cooling floors, for carburizing box cooling floors, for loading and unloading space, for storage of unworked steel, and for storage of supplies, such as fire clay, pots, lead, cyanide, tools, etc. With these in hand we are ready to work out a thousand or more combinations, one of which is the best; to develop hundreds of new ideas of handling our work; and to forestall many mistakes, which if overlooked and built into the plant, will prove expensive. We can at the same time, discover the best routing for work from receiving to shipping room and be prepared to establish this route for our employes. We are going to be assured of having sufficient capacity for every operation, with an allowance for an overload on each unit. We will have an orderly department; and if the mistakes are all made on the plan before the actual building is commenced, and are corrected, first individually and then in their relation to all other points in the finished plan, we will eliminate most of the usual changes encountered in any building operation. A change of location of one single unit often makes it necessary to alter the entire plan, but it is better to make the mistake on paper, than in the building.

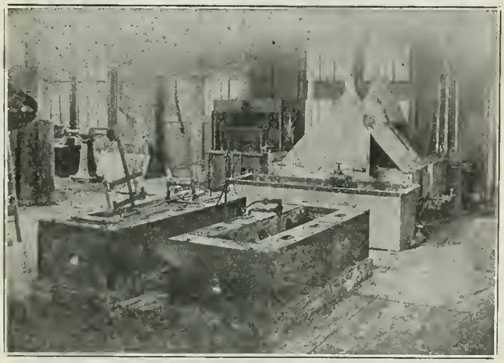

Fig. 7—Above will be noticed the grouping of the lead, cyanide, saltpeter, and oil baths. This unit consists of seven furnaces and two tanks. All pipe is carried in a small trench between the furnaces.

Inasmuch as no two plants have the same parts to treat, the same steels, the same treatments, or the same amount of productin it is impossible to specify any exact furnace arrangement. We must therefore continue to deal in generalities. If the plant is so large that separate floors or separate buildings can be used exclusively for each branch of the work, our problem is greatly simplified, but this is rarely the case.

By referring to the floor plan, one can see how the above points have been worked out. The finished plan looks ridiculously simple, and one wonders how there could be any other way of laying it out; but another problem, to meet other conditions, will present difficulties requiring an equal amount of thought; and when that is completed it, too, will look ridiculously simple.

In the sketch it will be noticed how the furnaces are grouped, not only to insure economy of space, efficient handling of the steel, appearance of the department, simplified piping, and rotation of operating, but also with regard to the comfort of the workmen.

From this point on our discussion will deal with a number of miscellaneous details of construction and operating practice.

Provision for a large supply of oil should be made. If the oil is brought in car load lots, a decided saving is effected. Storge capacity equal to at least two large cars is not any too much, because it often happens that a car is delivered, emptied, and another car immediately ordered. Then along comes an unexpected lull in production that does not allow the department to use the anticipated amount of fuel. If the second car is delivered it may stand on the siding several days before storage capacity is available. The demurage would soon pay for the additional required tank capacity.

The usual practice is to use steel tanks for oil storage. The only precaution that must be taken is to have them weighted down, so they will not float to the surface. An instance of this kind occured recently, when a firm buried a large tank in sandy soil near their plant during the dry months. The tank was filled with fuel oil, and remained filled until the wet weather came. Then a car of oil on order did not arrive promptly. Water had settled in the sandy soil surrounding and covering the tank. One morning, when the oil had nearly all been pumped out, the tank rose to and above the surface of the ground. The pipe connections were broken, and it was impossible to reset the tank until dry weather came again. Concrete saddles should be built on top of the tanks heavy enough to hold them down when they are empty.

The reinforced concrete tank is rapidly gaining favor. It is easy to build a perfect container, and for any capacity over 20,000 gallons it is cheaper than steel tanks holding the same amount. (An article in a future number of this magazine will describe the construction of a two compartment concrete tank holding 30,000 gallons of fuel oil, and 10,000 gallons of quenching oil.)

A large quenching oil capacity is very important, because neither maximum nor uniform physical properties can be obtained unless the oil is below a certain temperature. The capacity required will be regulated by the volume of work to be treated. There are many devices for keeping the oil cool, but working on the proven theory that a water spray has a very great cooling value, we find that a spray playing over a bank of 20 foot lengths of 1½-inch pipe gives very good results. Notice in the accompanying illustration that additional coils may be added this side of the ones shown and then both banks can be increased to any number of coils by lengthening the upper and lower headers to the left. The hot oil is drawn from the quenching tanks and forced by a pump installed for this service alone, into the lower header, up through the coils, and returns to the large supply tank by gravity. The water becomes warmer as it passes down over the hot coils, therefore the warmest water comes in contact with the warmest oil pipes at the bottom, and at the top the cold spray strikes the coldest one of the progressively cooled pipes. In summer 10,000 gallons of quenching oil can be held to a temperature between 70 and 80 degrees. In winter the water spray is not necessary. The wooden partitions shown in the picture are to confine the spray when the wind is blowing.

If all of the pipes and valves in the department are painted different colors to indicate what they are carrying, and if an arrow is painted on each side of the valves and elbows, showing the direction of flow, it will be much easier to trace the lines, find the right valves and make repairs. If one of the lines should break, this will often save considerable time in shutting off the flow; and the danger will be minimized if the break should happen to be in a fuel oil line.

Emergency valves should be placed on the gas, fuel oil, and quenching oil lines, at some point outside the building, and every employe instructed that in an emergency he must close these valves. We have seen serious fires prevented and hundreds of gallons of expensive quenching oil saved by valves installed in this manner. A master electric switch controlling every piece of equipment in the plant should be installed at some convenient point and also used in emergencies.

If a basement is not desired under the entire plant, a trench may be used. In the accompanying photograph it will be noticed that the furnaces are straddling the trench and that all of the pipe lines are carried on the side wall in a clean, neat, orderly, and accessable manner. In the entire plant no pipes should run overhead except the air lines and electric conduit. The lines in the trench can not be injured, are easily repaired, and in case of a break are not dangerous. A gutter along one side wall carries any possible leakage and overflow to a sump connecting with the sewer.

All of the tanks in front of the furnaces should be connected up so that they may be used for either oil or for water. It is not good practice to have the lines all piped up so that by closing one valve and opening another, an immediate change can be made. If it is done this way the operator may make the change in the inlet but neglect the outlet, and the quenching oil might go to the sewer, or waste water drain back to the quenching oil tank. It is better to break joints, plug the pipes not required and couple up the desired lines with pipes previously fitted, and hanging handy in the trench near the tanks.

The arrangement of tanks shown in the photograph allows each bath to serve two furnaces, permits more rapid handling than is usually possible, uses a minimum amount of floor space, keeps the center of the room clear and keeps down the cost of installation and repairs.

In planning and maintaining our department the comfort of the workmen should be kept constantly in mind. There is no sense in having poor working conditions when a little thought will eliminate most of the objectionable features, and we know there is no use installing expensive and delicate operating, recording and testing equipment if we are not able to attract and hold the class of labor qualified to use it intelligently. In spite of every known mechanical check, the uncertain human element is still the determining factor.

We do not know of any branch of industry that has as many variables as does the heat treatment of steel. After every precaution has been taken and every other test made, nothing but a breaking test will tell us the absolute condition of the finished piece in question. This is an impractical impossible test, therefore we must build our plant, install our machinery, select our checking devices, establish our tests and build our organization all so efficiently that the variables will be, as nearly as possible, a negligable quantity. A good man can turn out good work with poor tools; but when properly equipped he has a much better chance of maintaining a high standard. The same applies to a heat treating department. Only in a well conceived and well conducted department may we expect to turn out uniformly high class work and maintain a high production schedule.

The Basic Open Hearth Process

Various Basic Open Hearth Steel Making Methods in Use—General Considerations Relative to Steel Quality—Efficiency of This Method Ranks It Foremost in Steel Manufacturing.

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PART II.

THE basic open hearth process, making it possible to operate with widely varying percentages of pig iron and scrap in the charge, can more readily than any other steel making process accommodate itself to local conditions without undue increase in costs, and for this reason has had more modifications than has other processes.

Allowing for a cropping off from the average ingot of 25 to 30 per cent between its initial bulk and final form as placed on the market, a final return of nearly all steel and iron scrapped in service, deduction of the amount used in blast furnace, bessemer and acid open hearth, and for a normal increase in demand for steel products year by year; then the charge for the basic open hearth furnace will tend to approach an average of 40 per cent steel scrap and 60 per cent iron. In localities where pig iron is relatively high and scarce, the scrap charge may be very high in rare cases nearly 100 per cent, when coke must be charged to give carbon in melting. This may also be the case where an open hearth plant has been built where a bessemer plant (a very small user of scrap) already existed, which condition may reduce the pig charge as low as 40 per cent. Other localities may have a relatively cheap and plentiful supply of iron. The usual arrangement in this case is a duplex plant (bessemer and rolling furnaces) in combination with stationary open

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Note—From a paper presented at the fall meeting of the American Iron and Steel Institute in New York, October 28, 1920.

hearth furnaces, and in practically all such cases it will be found that the duplex plant has been added last to the equipment, as means of best adjusting the production of steel to the available charge. Stationary basic furnaces do not operate to give good practice on a charge running higher than 60 per cent pig, because of excessive overflow slags, and comparatively high losses. It is therefore deemed economy to use the duplex plant as a balance and since it for the most part takes its charge entirely of blown metal and adds, through its product, to the supply of steel scrap for the stationary furnaces, it helps greatly in giving them a satisfactory adjustment of scrap to pig iron in order to operate at best efficiency.

By far the largest part of the basic open hearth tonnage is produced in the stationary furnace and the large part of this tonnage is made by a combination of the pig and scrap and Monell processes, the charge ranging from 53 to 60 per cent pig iron, for the most part molten. Limestone, ore and scrap are charged in order and after two or three hours, when the molten metal is added, a reaction starts and continues with oxidation of silicon, manganese, phosphorus, iron and to a small extent the carbon, forming a slag high in iron oxide and silica and low in lime and magnesia and containing a large part of the manganese and phosphorus, which is allowed to drain for the most part from the furnace. As the heat melts the lime forms the usual tapping slag. Such a procedure although causing a loss of iron and manganese in the run-off, nevertheless makes for faster working on high pig charges and allows for satisfactory tapping slags on lower lime burdens, saving finally the extra iron as oxide that a more bulky slag would carry. As conditions warrant the lowering of the pig percentage below 50 per cent, then the decreasing ore charge, as scrap charge is raised, and the lower initial content of silicon, manganese, etc., tends to automatically make the operation a pig and scrap process.

In two cases only is the duplex used because that process suits conditions metallurgically better than does the pig and scrap process, and produces a product economically that would otherwise be more difficult. The first case is due to high chromium pig irons, which condition can be better met by first bessemerizing and then working through the basic open hearth furnace. The second case is of the South, where with pig irons running .80 to 1.00 per cent phosphorus, it is extremely desirable to desiliconize and decarburize in an acid bessemer converter, and on the transfer to a basic open hearth furnace of the rolling type with the careful exclusion of the converter slag, refine under a slag formed from a nucleus of lime and iron oxide so as to reduce the phosphorus in the steel and form a slag rich in phosphoric acid (well above a minimum of 18 per cent phosphoric acid) which can be skimmed off for final preparation as fertilizer and a new slag made, finally reducing the phosphorus content of the steel below .04 per cent allowing the steel to be tapped and finished in the ladle by necessary additions; or, the metal, with phosphorus reduced to .07 per cent and phosphorus in the slag well above the minimum required in the use as fertilizer may be transferred to another furnace and finished.

The uses of the duplex process other than the two cases cited are primarily for rapid production under conditions where pig iron is relatively easy to obtain and a balancing of scrap supply as before described is necessary. Tilting furnaces, for the 100 per cent blown metal charge, are preferable because of the ease in getting rid of the excess slag at time of reduction. The charge other than that of starting up may be two-thirds to three-fourths blown under ten carbon followed by a high carbon ladle called the "kicker." This is the more common practice. Better practice is the use of molten pig iron as the "kicker" because of the large amount of manganese introduced. In this respect, the general absence of manganese in the bath, the duplex process is at a disadvantage. Balanced against its frequency of tapping (heats range from 1½ to four hours tap to tap) is the additional loss in conversion of 3 to 4 per cent.

The cost of plant complete per ton of ingots will be practically that of the cost of stationary furnaces per ton. As for the quality of duplex steel as against the product of the stationary furnace, it supplies a large amount of steel for the trade and for many purposes satisfactorily. There is ample field for its output and unfair comparisons with stationary furnace products that require considerable extra attention in the making are unnecessary.

Definite results in making high quailty steels can be attained a little more often in the acid furnace because acid furnace slags adjust themselves more readily and attain more nearly equilibrium, thus restraining the unbalanced activities of iron oxide with respect to the bath. The stationary basic open hearth furnace on its usual pig and scrap program provides a considerable margin in this respect over the duplex process, and allows for greater control than is possible with the violent reactions due to the "kicker" and the difficulty in limiting to the right boundary of action, the swift, powerful reactions so necessary for speed. The lack of manganese in the bath is under these circumstances a more serious disadvantage, coupled with the necessary practice of large additions in the ladle and so little time for inclusions in either furnace or ladle to rise. If good steel is to be made by the duplex process it is necessary to have a sufficient amount of manganese in the bath as well as in the slag.

To provide a very flexible system as to expansion and contraction output, to retain the advantages of rapid decarburization and desiliconization of the bessemer converter and the advantages of balancing up of pig and scrap supply, the use of blown metal in a stationary furnace with both scrap and molten pig iron offers great inducements and in the long run finds a broader application than the straight duplex. Considerable increase in tonnage over the ordinary ore, scrap and hot metal charge is possible, and a residual manganese of fair amount will be present. The product will be practically equal to that of the usual stationary furnace process in quality.

The Bertrand-Thiel and Hösch processes, whose application are as yet confined to Europe, have been considered in this country because of their use of a furnace to carry out the roughing stage for elimination of silicon. It has been considered advisable to make the "roughing" furnace more nearly a large mixer, considerably larger than the finishing furnaces, and operating at lower temperature. Silicon in this washing furnace would be largely eliminated. Manganese would be eliminated in rough proportion to the silicon, the less eliminated, however, the better. Carbon would be reduced but very little.

Phosphorus would be affected to greater or less degree depending on the temperature, the amount of oxides charged and lime fed, and on the desire for high phosphate slags in the finishing furnace when desirable for fertilizer. It has been thought possible by these means to avoid the large losses in bessemerizing and gain iron from large ore additions in the primary furnace or mixer. There is as yet insufficient understanding of the best method of working the process or the best field for its use, but it has inherent possibilities in promoting a greater output at more regular intervals, while turning out a product of good quality.

Little can be said about the compositions of pig iron desirable without going extensively into the practice and requirements of many plants. Average basic requirements call for a silicon averaging 1 per cent, phosphorus has as yet not been troublesome, sulphur should be preferable under .040 per cent since the open hearth process can do so little to reduce its contents in the charge except by wasteful expenditure of time and wasteful use of manganese. The manganese content varies quite widely by reason of certain desired benefits in the process. The manganese content and the quality of pig iron in general will be further discussed in the following paragraph. For duplex plants, iron of bessemer quality except as to phosphorus is of course necessary, with silicon content ample to insure warm bessemer blows and manganese not so high as to permit "slopping". The sulphur content as in case of the basic iron must be regulated to the specifications of the trade.

The use of molten metal, dating back nearly to the beginning of the process has increased with the development of output until at the present it constitutes the greater part of the iron charge. Its use effects decided saving in time and fuel. The metal mixer has further contributed greatly to the economy of the process by giving a greater regularity to the supply and a more nearly constant chemical composition.

By far the larger part of the pig iron for basic open hearth use is graded and accepted on analysis only and very little attention is now paid to the physical characteristics and condition of the iron, except in the case of a few plants where it is bought in pig form and graded on both analysis and fracture, following a practice that has given good results in quality production.

High manganese pig iron has found quite extensive use in the making of steel of required quality in the basic open hearth furnace. The general methods of procedure are, to make practically all the basic iron high in manganese, say 1.50 to 2.00 per cent, or to concentrate all attention in this respect on certain of the highest quality products with a pig iron from one or two blast furnaces running up over 2 per cent, using a low manganese basic iron, say .90 to 1.10 per cent, for the balance of the product. The general difficulty in the case of spreading the high manganese iron over all the product is the large manganese loss in the run-off from the average trade heat with high pig percentage. Undoubtedly the greater return is ultimately in concentrating the high manganese iron in the higher quality heats where the usually lower pig charge makes for a higher residual manganese and higher manganese content of tapping slag, because of a very small or no run-off slag.

There is possibly no element that functions so well in both steel and slag as does manganese. In the first place it confers fluidity on the slag as well as basicity. It tends to prevent the absorption of sulphur by the iron in all stages of the heat and to break Fe S when formed. It acts in the latter stages of the heat to deoxidize the bath and to lessen the total amount of non-metallic inclusions. Very careful study of conditions arising in finished steel for varying manganese content of pig iron used, made at the South Works of the Illinois Steel Company, has shown its effect in helping to control the influence of high sulphur fuels and its general effect in giving a lower sulphur content in the steel together with a better quality. For example, the value for sulphur content in the steel and for rejection at the rolling mills over a stretch of 4,336 heats show increasing sulphur content in the steel, and increasing rejections on the product of the rolling mills as the manganese content of the pig iron is reduced. For iron of 1.90 per cent manganese a sulphur content of .034 per cent is shown and a figure for rejections of 7 per cent, and an increase in sulphur content to .04 per cent and a figure for rejections of 10½ per cent for iron of 1.15 per cent manganese. Manganese in pig iron, through its subsequent presence in slag and steel, is admittedly an aid towards the correction of bad influence and tendencies in steel making and certainly allows us a little more lee-way in use of high sulphur and poorly refined, nonuniform pig irons. Some claim that it helps towards more regular working in the blast furnace.

We must allow for all the cases where manganese comes in to round out processes and add the necessary refining action for good product, for all the benefit derived in the manufacture of very fine steels, but we must certainly count the cost when manganese is used in an attempt to correct the evils of bad iron making and bad steel making. We must admit first that all the effective manganese added in the pig iron is not available in slag and steel because of losses in the run-off slag of the average heat, unless we slow down the production by retaining all products of oxidation of silicon, manganese, phosphorus and iron in the furnace, charging a larger amount of lime, and in the long run ending with a slag too large and unwieldy, which restrains rather than helps the effect of both carbon and manganese. Manganese being an expensive addition in pig iron, and allowing for the fact stated as to amount of manganese in the average heat available for the good effect it has, then we must make very conscientious efforts to improve the quality of the pig iron and eliminate to as great an extent as possible, poor quality high sulphur irons, and to make every effort count in promoting correct principles and methods in our steel making, rather than pay for the manganese that must correct deliberate points of omission and carelessness, in addition to that amount which justifies itself. Manganese ore can be used to good effect but not so economically as high manganese iron. Manganese oxide is more readily reduced in the blast furnaces and functions better in the steel by working from steel to slag.

The attempt to work pig iron high in sulphur into the charge by use of heavy lime burdens is one that is extremely wasteful of time and material as against the results obtained. The large amount of lime makes for excessive volume of slag, for poor transfer of heat to the steel, and this condition is further complicated by the viscosity of the slag which tends to hold larger amounts of iron oxide in its attempts to attain fluidity at the proper temperature for steel making. Manganese in the pig iron is here an aid through its oxide in promoting fluidity but its use is comparatively expensive as against the net results obtained. Sulphur is so much more readily and cheaply eliminated under the reducing conditions of the blast furnace that the attempt in the basic open hearth furnaces occasions a net loss.

High sulphur content in the pig iron is very often an indication of bad conditions in the blast furnaces, attempts at a reduction of the basicity of the blast furnace slag, of variations of temperature in controlling the silicon content, and we have rather fallen into the habit of attributing the sluggish pig iron and the bad results obtained in working the subsequent products of the open hearth furnace to the sulphur content of both pig iron and finished steel. Thoroughly reduced, "rich" pig irons are absolutely necessary to good steel quality. The use of pig iron from special furnaces, where the effort was constantly directed towards an output of uniformly good iron, and from which no iron made in periods of irregular working, was accepted for high quality steels, has been found of great benefit in the manufacture of armor steels at the Homestead Works.

Very high quality forging steel has been made at the Homestead Works by use of both high and medium manganese content of the charge and a brief discussion follows. No high manganese iron being available, the manganese was charged in form of spiegel both with the pig iron and in subsequent additions to the bath during the working of the heat, the total amount added being equivalent to 5 per cent manganese in the iron charged and 2.20 per cent in the total charge. The resulting slag averaged 12.8 per cent Fe. O. (all iron oxide estimated in this form) 14.5 per cent SiO_2 and 18. 85 per cent Mn. O. The residual manganese at tap was .41 per cent. In the regular practice in making this steel the manganese content of the pig was 1.25 per cent and the content of the total charge .06 per cent. Two additions of 60 per cent ferro manganese were made during the last hour of working the heat, totaling .53 per cent Mn. as referred to the total charge. The resulting slags averaged 15.85 per cent Fe. O., 19.10 per cent SiO_2. and 10.97 per cent Mn. O., and the residual manganese was .24 per cent. The second or regular procedure worked equally as well as that using very high manganese content in the charge.

This will introduce the question of the relative merits of the procedure where manganese is present in pig iron and the heat during melting and working, and that where lower residual manganese exists during the working of the heat but with manganese added in concentrated form as spiegel or ferro manganese in the last stages of the working. The latter procedure serves to obtain very excellent results in the deoxidation of steel and the elimination of inclusions and is more economical in manganese. Both methods give excellent results in making high quality steels and like many other questions in steel making, many careful comparisons must be made before we can generalize by saying that one or the other is better.

The slag, notwithstanding the fact that it is the medium, during the major portion of the heat through which heat is transmitted to the bath of metal, for the completion of the oxidation, and for the larger part of the refining action, has had comparatively little study in its relation to "every day" production. We cannot arrive at "worth while" conclusions in this study so long as we compare slag analysis as revealed only through the percentage of the various oxides present. There is an absolute necessity for the comparison of the weights of the elements as oxidized and going into the slag, which means a knowledge of the usual relation of the slag weight to charge and of the relations of weight of tapping to run-off slag when the latter enters into the process. The determination of slag weights and the relative weights of the elements oxidized and going into the slag need not be made nearly so often as the slags are sampled and analyzed. The last mentioned work should be done frequently and the analysis by weights applied at intervals for check. Only by such painstaking methods can we arrive at the best slag volumes necessary for the best relations of quality and production, and from this we get the necessary lime burden to give the necessary basicity relative to the acids present plus an excess up to the point where the slag is sufficiently fluid and also neutral to the hearth and greater lime additions interfere, through promotion of viscosity, with the heat transfer through slag to steel and the proper functioning of the slag. Viscosity further introduces the factor of increasing slag volumes, since the slag in adjusting itself to a condition of fluidity necessary at its temperature, takes up iron as iron oxide from the bath or retains iron oxide from oxidizing additions made to the bath, thus increasing the losses, while at the same time introducing again the factor of increasing difficulty in transfer from flame to steel through the greater slag depth.

A careful checking of the amount of heat necessary to raise the slag to and maintain it at the tapping temperature, and comparison with the amount of heat necessary in the steel for the same purpose, will reveal the fact that considerable heat used in excess slag volumes could be made available for the production of steel. We can therefore have the following factors as affecting slag weights and which can reduce the amount of heat necessary to raise the slag to the tapping temperature and keep it sufficiently fluid, thus giving a better proportion of heat to the bath of the steel.

(a) The quality of materials charged and particularly the pig iron. The good charges necessary in high quality production therefore give incidentally a better slag volume for good working.
(b) Careful consideration of the weight of lime charged.
(c) Early removal of a portion of the slag in those cases where high percentage of iron in the charge together with the quality of the iron, make for large amounts of the products of oxidation which dilute the lime additions and raise the slag volume.

Manganese must here again be mentioned for its effect through its oxide in the slag in promoting fluidity while at the same time increasing the basicity, for its effect in reducing the iron oxide content of the slag, its tendency as a desulphurizer, and final effect in aiding in the removal of nonmetallic inclusions.

Pouring temperatures have received a great deal of discussion during the last three years because of the necessity of making very large tonnages of ordnance material and very important uses where lightness was desired with strength. Many definite opinions were expressed as to the part the temperature of steel have in the production of flakes, woody structure and oxide inclusions, and where in some cases applied in an attempt to generalize statements as to pouring temperature in their application to various steel making methods in many plants, without having real quantitative data as to temperature. Long continued observation of pouring temperatures on certain classes of steel of fairly definite composition and with ingot volume fairly constant, lead on to the belief that observations, even with the best methods, are relative and must be applied only to the work in hand. An indication of the fluidity of the steel as observed from the formation of skull in the ladle is probably at present the best indication of the temperature of the steel at pouring.

In one campaign of extremely high pouring temperatures at the Homestead Works we were struck by the greatly increased cutting of the refractories of the ladle lining. This raises the point as to whether very high temperatures at tapping and pouring as a result of an effort to rid the steel of inclusions does not make later conditions in pouring which may introduce a larger quantity of foreign material into the steel and with very little time to rise. Steel poured at a temperature which makes for a condition very slightly above the skulling point has been found very good inpractice in making alloy steels. For general conditions of steel making, the evidence of a very small skull shows best temperature at pouring.

Much can be said of the methods used at the end of the process in making alloy additions, of the desirability of eliminating as much as possible the "killing" of the steel in the moulds and of the merits of bottom pouring against top pouring. In a general discussion of the process within the confines of this paper, brief comment only can be made and a presentation of the various subjects must be left to other papers.

Nickel additions can be made in the initial charge with but slight losses. Chromium, due to its high oxidation losses is best added as an alloy of iron and chromium in the bath before tapping with sufficient time, a maximum of 35 minutes is usual to thoroughly melt the alloy and give uniform bath content of chromium. The loss of chromium by this addition ranges from 20 to 30 per cent, depending on the carbon content of the bath. Managnese additions on high quality steels are best made in the bath before tapping. Quite usual is a combination of bath and ladle additions of manganese, with a growing proportion of manganese in the bath addition as we approach the higher quality of steels.

The loss of manganese in the bath is usually twice that in the ladle. The use of crushed ferro manganese through a chute promotes efficiency and also uniformity of content in the steel in the case of ladle additions.

Molten spiegel additions in the ladle have been used largely in making manganese additions on high carbon heats, such as rails, and the carbon content of the addition naturally restricts the use to such high carbon heats.

Ferro silicon for the silicon addition must be made in the ladle because of great losses resulting from oxidation of bath additions and the danger of rephosphorization of the steel. Introduction of finely ground ferro silicon through a chute into the tapping spout of the furnace as the steel is running out gives very good results in obtaining uniformity of silicon content and reduces the loss of silicon as low as 20 per cent. In this, the addition of silicon to the steel, the acid furnace has many advantages.

There is a growing tendency towards the elimination of methods of deoxidation as applied in the ingot mold by powerful deoxidizers, such as ferro silicon and aluminum. Exceptions are made in the case of shell steels and other high carbon steels where even slight porosity is objectionable. It is in general, thought better at the present time, to take "preventive" measures during the making of the heat, rather than attempt to "cure" by rapid and powerful deoxidation at the last stage, which is the pouring of the ingot. Small amounts of deoxidizers may be used to advantage at times in preventing sponginess in the solidified ingot, but not those amounts which cause such rapid solidification of the top of the ingot that the gases have but little chance to be liberated from the ingot, and which tend toward the formation of pipes and gas pockets. Considerable discussion is necessary to bring out the proper uses of such deoxidizers. There is a great need for deoxidizers whose products of oxidation are easily fusible at pouring temperatures so that they will unite and rise to the top of the ingot.

There is also a growing tendency towards a recognition of the proper place that bottom pouring has as a method and a better recognition of the merits of top pouring. Bottom pouring as applied to the steel product as a whole can be considered as useful only where very smooth surface conditions in the finished product are desired, and with little regard for the interior condition of the ingot. More careful regulation of the speeed of pouring has greatly improved surface conditions in top cast ingots. The advantages of churning action in pouring towards the better elimination of gases from the ingot before solidification and the better temperature allowed for pouring (considering the extremely high temperature necessary in pouring large groups of bottom cast ingots) make for a final soundness and uniformity of product not usually obtainable by bottom pouring methods.

Conclusion.

Notwithstanding a full appreciation of all that has been contributed to the art of steel making by the various methods in which the basic open hearth process is applied, there is among thoughtful open hearth men a very definite belief that much can be done towards future improvement and that the possibilities are fully as great as they have ever been. The growth of capacity, it is true, has outstripped the growth of efficiency in the methods used in employing the process, but we are getting, gradually, a better vision of our responsibility in applying methods of conservation to our resources of fuel, to the heat energy in our furnaces, and to what is of greatest importance, the great problem of labor-saving.

All the greater are our responsibilities and obligations in the task of advancing the art of steel making when we consider all that science and engineering can contribute if we can thoroughly realize our needs and so present them, doggedly, perseveringly, day by day, that both science and engineering will be constrained, even inspired to help us in their solution. Science must also help us, to a measure undreamed of in the past, in the solution of many of the problems which are confronting us in the use of our resources of raw materials for the production of steels on which there are placed ever more severe requirements, and we must keep before us the fact that there is ever an increasing need for quality in our product.

The basic open hearth process embodies a great and enduring principle which may for many years find application in our steel making processes, although through instruments and methods of which we as yet have no conception, or knowing of them, have not yet the vision that lets us see them in terms of their ultimate economic value to us.

The Logic of Roll Design

Discussion Showing the Simpler Methods of Slabbing and Preventing Overfill—Experiments Noted Which Show the Logic of Using Particular Rolls on Special Mills.

By W. H. MELANEY.

PART II.

HAVING shown in the previous article the method of rolling, and the type of rolls used in reducing an ingot into a round or square bar of small section, the present article will deal with some of the various sections, the production of which bring into use, principles of design based on entirely different conditions, and calling for entirely different methods, of preventing overfill or finning, as well as showing how the reduction of the steel is compelled to take place in the open part, rather than in the closed part of groove to get the benefit of the slabbing action.

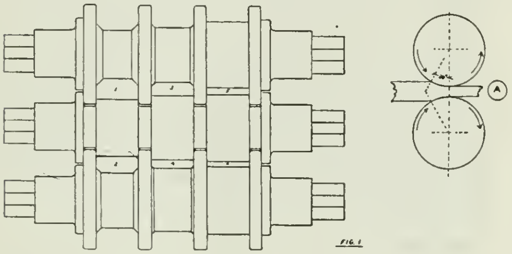

FIG. 1

Fig. 1 shows a set of rolls for producing ordinary rectangular bars, known to the trade as flats. In these rolls you will note that either a square or rectangular billet, from a roughing set of rolls is given a number of passes through these finishing rolls, in what are known as tongue and groove passes. These passes being generally used both top and bottom in the same groove.

Now if no provision was made to prevent it, the reduction in thickness of the billet in each pass would cause the steel to force its way between the side of the tongue on one roll and the side of the collar on the other roll, leaving a fin on the side of the bar that was next to the tongue, and on the next pass, these fins would be rolled in or lapped over and two more produced on the opposite side of the bar. This would happen all the way down to the finished bar, with the result that the bar would be worthless as a merchantable product, because all four edges would be made up unwelded, rolled in seams.

So some method had to be evolved to prevent this, and common sense suggested the easiest and most logical preventative. This was to remove the metal from the corners of the bar, where the sides of tongue and groove met, and this was done by leaving a fillet in the bottom of the groove in each preceeding pass. Reducing the size of this fillet in each succeeding groove to suit the amount of the reduction. The finishing pass, and on thick flats, also the leader pass having the corners of the groove turned square and sharp, in order that the finished bar may have square sharp edges. There usually being sufficient bluntness in the corners of the bar, previous to the last pass, to prevent any overfill with the slight reduction given on the finishing pass.

The production of this class of material has presented no greater obstacle than that of slabbing down the steel with proper protection of the corners, except that there is a limit to the amount of reduction that can be given the steel, and still have it enter the groove without difficulty. The amount of this reduction depending upon two conditions, the diameter of the rolls and the hardness and heat of the steel being rolled.

From a number of experiments made at various times by different experimenters it has been determined that in ordinary practice a line drawn perpendicularly through the centers of the two rolls (See Fig. 1-A) when they are placed a distance apart equal to the thickness of the bar after being reduced, and another line drawn from the center of the roll, bisecting its periphery at a point where the thickness of the bar before being reduced just touches the outer circle, should not exceed an angle of 30 degrees for the heaviest reductions on ordinary soft steel.

You will note that the greater the diameter of the rolls, the greater the reduction indicated.

Another approximate rule that has been suggested is that no billet should be entered into a groove in rolls of any diameter, that exceeds in thickness, one half the distance between the centers of said rolls, measured perpendicularly when the rolls are in contact. This only holds good on very soft, well heated material.

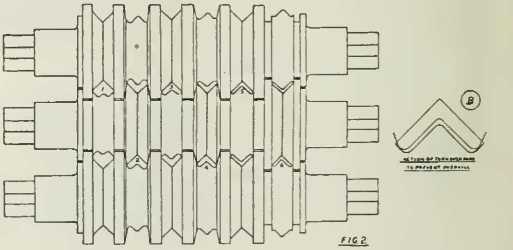

FIG. 2

Rolls for Producing Angles.

Rolls for producing angles are turned in various forms, depending upon the shape of the billet from which the angle is to be rolled. But each method makes use of the plain slabbing process same as used on a flat, except that a slightly different method is used to prevent overfill.

If the angle has equal length of legs it can be rolled from a square billet entered diagonally into the first groove and in which two sides of the billet are used to form the sides of the angle. But here again the problem presents itself of the tendency of the steel to force its way between the tongue and side of the groove of the roll, (See Fig. 2) and this must be prevented. Now, due to the shape of the groove, the old familiar fillet as used in flat rolls is impractical, therefore it necessitates a form of groove for this purpose, that is known when used on two high rolls as the turnover pass; because on two high rolls the bar had to be turned over before entering this groove. On three high rolls this same action is obtained without turning the bar over. This form of groove was designed for the express purpose of rounding off the corners of the angle where the tongue and groove met on the next pass, thus shortening it sufficient to provide spread to prevent overfill (See Fig. 2-B) this occurs on every other pass, except of course, that the finishing pass is left sharp and square on these corners.

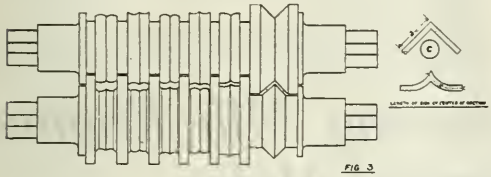

FIG 3

It is usual to roll these angles with the apex up in order to better the delivery and prevent the point from being worn off on the guides. Rolling the angle in this position necessitates placing the pitch line or rolling center of the angle at a different level because the point of the angle being up is chilled by the water used on the rolls when rolling and the under side of the angle being protected from the water, stays hotter, therefore elongates more and causes the angle to turn up on leaving the rolls. So the diameter of upper part of the groove must be increased in order to hold it down firmly on the delivery guide.

Another method of rolling angles, and much used on the larger sizes, is the butterfly or opened out angle. (See Fig. 3) in which the process is exactly similar to rolling a flat, except that the final shape of the bar to a 90 degree angle is produced by bending it up in the last pass. You will note that in this method the same type of fillet is used to prevent overfill, as is used in the flat rolls.

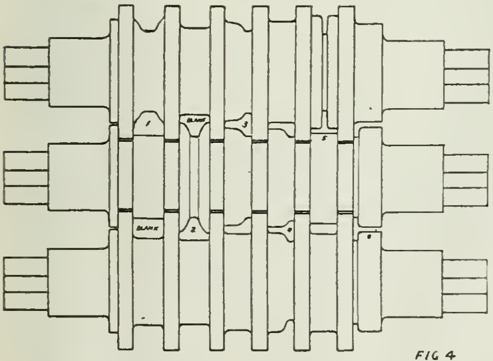

FIG 4

This bending up process of the last pass, due to the stretching of the sides of the angle when they are forced out straight, introduces another feature.

You will find that the outside of the curved side of the angle on the groove before the bending up groove, if measured with a flexible rule, does not measure up to the true length of the side of the angle you wish to produce. If it did, when bent up to 90 degrees the outside of the angle would be too long and as a consequence the end of the leg would not be square. So, to prevent this, the length of angle is measured at the center of its thickness. (See Fig. 3-C). This method not only produces a perfectly square edged angle, but as considerable taper is used in the sides of the collars of the grooves, the grooves are brought back to their original width, each time the rolls are dressed.

Another excellent feature of this design is that a flat billet is used, and as the grooves do not need to be so deep as where a square billet is used, the rolls are much stronger, because the diameter at bottom of grooves are larger.

T-Iron Rolls.

The rolls used for rolling T-iron present another different feature that must be taken care of in order to produce the proper section. As this section has the form of a T at least one of its legs would have to be rolled in the closed part of the groove, that is, that part of the groove in which the action of the other roll has no effect, and in which the metal can not be made to enter except under conditions that will be explained later on, and a slabbing effect must be resorted to in order that the section may be reduced sufficient to drop into these closed portions of the groove.

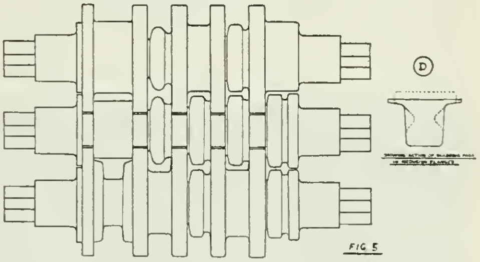

FIG 5

Fig. 4 shows the method of slabbing the billet to produce the top and vertical shape, and due to the position in which it is placed in the rolls, it delivers straight, and this would not be true if this excessive reduction was made with the groove at right angles to its present position. Then, by turning the T upright in one groove and flat in another, thus getting a simple slabbing action on each, the vertical leg of T being permitted to drop into the closed portion of groove without side draft. The reduction in the thickness of the legs being taken care of by the slabbing action of the other grooves. The overfill at junction of tongue and groove being prevented by rounding off the corners in the closed part of pass.

Rail Rolls.

The same principle is used on rolling rails as is used on T-iron, except where the rail is rolled diagonally, when a certain amount of slabbing action is produced on the flanges without turning the rail upside down as is ordinarily done.

Fig. 5 shows the ordinary type of finishing rail rolls in which a squabbing pass is used to reduce the flanges of the rail and also bring the blank to the proper height. this takes a formed billet from the roughing rolls (See Fig. 5-D) and by the simplest direct slabbing action. reduces the comparatively heavy section from which the flanges are to be formed, to a thin flange that will drop into the closed part of the next groove and these thin flanges are retained through all the other passes used to form the web and head of the rail. The height of the flanges being reduced in each succeeding groove to take care of elongation and keep them up to section. The head of the finished rail being formed half in each roll on the last or finishing pass, the parting of the rolls being at the center of the top of the rail head.

Overfill is prevented at juncture of tongue and groove, as stated previously, by rounding off the corners in the closed part of the groove.

The design of rail rolls shown in illustration are such as are used in ordinary merchant mill practice, but where rails are rolled as a specialty, the same principles in designing the grooves are used as shown, but the grooves are arranged in several sets of rolls. to suit the conditions of the practice in use at that plant.

In mills of this special type, the rail is rolled direct from the ingot to the finished rail in one direct continuous operation.

The diagonal rolling of rails together with beam and channel sections will be taken up in a later article.

44-inch Reversing Blooming Mill Engine Replaced by Electric Motor

Large Steam Engine Torn Out and Replaced by Electric Motor in Twenty-four Days—First Time Electric Power Has Replaced Steam on a Large Reversing Blooming Mill.

By B. M. JONES,
General Engineer, Westinghouse Electric & Mfg. Co.

FOR the first time in the history of the American steel industry electric power has replaced steam on a large reversing blooming mill. Only two previous attempts have been made, in other countries to change from steam to electric power and in one case the steam engine was left intact for emergency purposes.

On December 7, 1920, the huge steam engine driving the 44-inch reversing blooming mill at the Steelton plant of the Bethlehem Steel Company, broke down. Work was started immediately to tear down the engine which, as had been previously planned, was to be replaced by electric drive. On December 31, the Bethlehem Steel Company started to roll steel with the new electric motor. Considering the tremendous task of tearing down the large reversing steam engine, blasting out its foundations, building the forms for the motor foundations and installing the complete electrical apparatus in working order, the time taken, only 24 days, is considered remarkable.

Inasmuch as the blooming mill is the only one in the plant it was important that the change-over to the electric drive be made in the shortest time possible. In addition it was also important that no time be lost in making adjustments or in tuning up the new equipment. To accomplish this it was necessary to have everything well organized and planned in detail, so that there would be no unnecessary delay. The forms for the reversing motor foundation were built up complete in two pieces as a template before the engine was removed, and after the old foundation was blasted out, these templates were set in position, the foundation bolts placed, and the concrete immediately poured. This materially shortened the time required to make the change.

The motor rolled 609 tons of steel the first day, 796 the second, and 1006 the third. The mill is now operating single turn, and is in no way curtailing the output in spite of the fact that due to shortage of power, under the present condition it is necessary to operate the equipment with a power demand not exceeding 2500 kw.

The electric drive consists of a double unit reversing dc motor, the necessary flywheel mg set for driving it, and a small exciter set, together with a blower outfit and the necessary switching equipment. All the machines except the blower outfit are mounted on the first floor of the motor room sub-station. The blower outfit is mounted in the basement and the switching equipment is mounted on a balcony. Lightning arresters are installed on the second balcony.

The double unit reversing motor, as shown in the illustration is a 600 volt adjustable speed direct current machine of the compound wound compensated type, having a speed range of 0 to 120 rpm in both directions. It is capable of developing 1,900,000 ft. lbs. torque momentarily and is directly connected to the mill.

Each armature of this motor is mounted on the forged steel shaft which is supported by two pedestal bearings arranged for water cooling and gravity oil lubrication. The bearings and frame of the motor are supported by heavy cast iron bedplates which is well anchored to the concrete foundation by long foundation bolts.

The motor is semi-enclosed and is arranged for forced ventilation. The blower equipment, installed in the basement, is interlocked so as to prevent operation of the reversing motor in case the blower is not delivering the proper amount of air to the motor.

Electrically and mechanically the motor is designed to withstand the overloads encountered in reversing blooming mill service, and in addition it is provided with a large thrust bearing on the pedestal nearest the mill to protect it from the mechanical shocks of the mill, such as the breaking of a spindle. The ease and rapidity with which this motor can be started, stopped and reversed shows it to be inherently adapted to reversing blooming mill service.

The motor is a compound-wound machine, the compounding being obtained indirectly by means of a small series exciter and a separate winding on the main poles of the reversing motor. Due to the extremely high-peak currents, encountered in the main circuit, it would be extremely difficult to reverse the ordinary type of series field which would be necessary to keep the proper shunt and series-field relation. Therefore, the series exciter and the separate field winding is used, the series exciter field being connected in series with the main-motor armature circuit, and the armature of the series exciter being connected across the separate winding of the main reversing motor.

The switches for reversing this field are operated from the master switch, which also operates the reversing switches in the field of the generator. By this scheme the compounding effect is obtained without the necessity of reversing the heavy armature current. This compounding of the reversing motor allows it to increase its torque on the overloads, and thereby better meet the severe shocks that are encountered.

Construction Features of Flywheel Motor-Generator Set.

The reversing motor receives its energy from two 600 volt, 367 rpm separately excited shunt wound, direct current generators of the compensated type, which are designed to withstand the same peak loads as the reversing motor. These generators are driven by a 3200 hp alternating current motor of the wound rotor type, which is designed to operate on a 3 phase, 660 volt, 25 cycle circuit. A 100,000 lb. flywheel is mounted on the same bedplate between the motor and generators. This flywheel is completely enclosed with a plate cover to reduce the windage losses, and also to afford protection to the operator. The flywheel bearings of this set are arranged for gravity lubrication and for water cooling as an emergency feature.

Operation of Liquid Slip Regulator to Control Input to the Flywheel M. G. Set.

A liquid slip regulator limits the peaks and equalizes the input to the flywheel set. When the load on the alternating current motor reaches a predetermined value, the regulator introduces resistance in the secondary of the induction motor which causes the flywheel set to slow down, thereby allowing the flywheel to give up a portion of its stored energy, and thus absorbing the peak load. When the peak load goes off, the regulator cuts out the resistance in the secondary circuit of the induction motor, and brings the flywheel set back to approximately full speed. The regulator is so arranged that the alternating current motor cannot be started until the maximum resistance is inserted in the secondary by means of the slip regulator being wide open. The switching equipment of the alternating current motor is so arranged that the flywheel set can be brought to rest within a short space of time by opening the forward primary oil circuit breaker and closing the reverse primary oil circuit breaker. This reverses one phase of the induction motor, causing it to

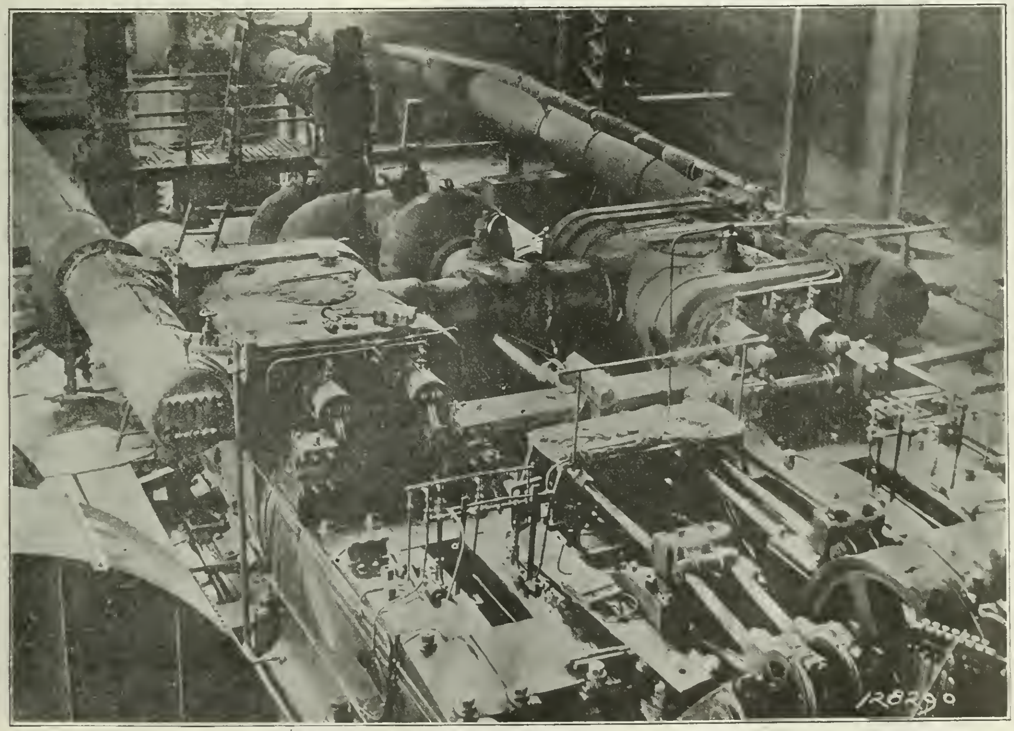

Fig. 1—Twin tandem compound reversing steam engine 36 inch and 60 inch by 54 inch which was replaced by electric motor at the Steelton plant of the Bethlehem Steel Company.

exert a torque in the opposite direction, and thereby bringing the set to rest quickly.

Special attention has been given to the manner of insulating these machines to withstand the dust and dirt usually encountered in a steel plant. The direct current machines were designed with the object in view of being able to withstand the severe overload encountered in this class of service. The rapid change of flux in the poles requires careful design to eliminate commutation troubles from which these machines are particularly free. The design of the machine to handle this class of service involves many wide departures from previous practice, and the exceptional service that these machines have given is a very good indication that they are liberally designed to withstand the abnormally high current encountered.

Motor Generator Control System Simple as Well as Effective.

The simplicity of this control equipment is clearly shown by the fact that the steam engine operators rolled steel at the first trial without any trouble whatsoever. The operators seemed very well pleased and surprised to find the ease with which the master switch was handled and the ready and sure response of the motor to the master switch.

The control of the main motor and generator is obtained by adjustment of the fields, the generator fields being reversed to obtain reverse direction of rotation of the main motor. The excitation of the motor shunt field remains in the same direction at all times. The speed of the reversing motor is proportional to the generator voltage up to normal voltage, and beyond that point the increase in speed of the reversing motor is obtained by weakening its main shunt field. The compound field, described previously, is adjusted to correspond with the speed of the reversing motor. The master switch is mounted in the mill for controlling the contactors which adjust the various field circuits of the motor and generators. The position of the master switch determines the speed of the reversing motor, and its direction of rotation. This system of control makes the operation of the equipment extremely simple and very easy to operate while at the same time obtaining a very rapid and effective means of control.

The reversing motor and direct current generators are separately excited, receiving their excitation from a small induction motor driven exciter set. The main direct current circuit breaker between the reversing motor and its generators is so interlocked that it cannot be closed unless the exciter set is operating properly.

Additional Equipment in Blooming Mill Motor Room Sub-Station.

The motor room sub-station is used for synchronizing the two power houses and there are installed on the first floor three 1000 kva transformers having a ratio of 2200 to 6600 volts, through which the power of one power house is stepped up to the voltage of the second power house. The oil switch and synchronizing apparatus necessary for synchronizing these two stations is located on

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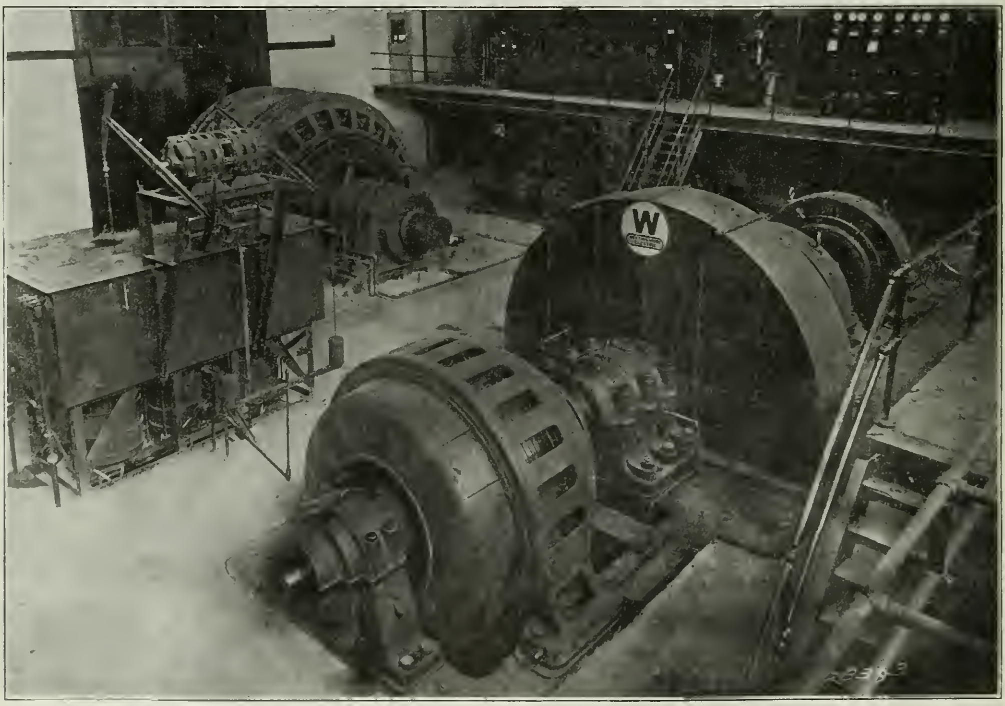


Fig. 2—A view of entire motor room sub-station. Note the difference between this illustration and Fig. 1, which shows the old steam engine. Only 24 days were required to bring about this change.

Herbert A. Andresen, Founder of the Blast Furnace and Steel Plant, Ends Remarkable Career

Herbert A. Andresen, President of the Andresen Company, Inc., was called by death on January 22, 1921. Apparently in vigorous health, he was attacked by pneumonia, and despite every effort to effect his recovery he succumbed after an illness of only a week.

Herbert A. Andresen, the son of Carl and Mimi Andresen, was born March 14, 1884, in Detroit. After receiving his early education in that city he entered the University of Michigan at Ann Arbor. Subsequently he was graduated from the Detroit Law College, and for a time engaged in the practice of law.

Possessed of exceptionally keen analytical faculties; an unusual power for grasping and assimilating details; an abnormal capacity for work; and a magnetic personality, which won the confidence and admiration of all with whom he came in contact, he would inevitably have risen to distinction in the legal profession; but the lure of technical journalism proved stronger than his love for the lawyer's life.

Turning his attention to publishing, he first became identified with the Penton Publishing Company of Clevland, and here his material aptitude for work in this field was at once apparent.

With the clear vision and excellent judgment which characterized his entire business career, he very early glimpsed the possibilities of a publication devoted exclusively to the operating problems of the steel industry. With steadfast confidence in this conviction, he launched his first independent publishing venture, The Blast Furnace and Steel Plant, which under his capable management was a success from the start.

In the industrial supremacy of Pittsburgh, Mr. Andresen recognized the evidences of a more logical field for the development of a publication so closely allied to the basic industries of Western Pennsylvania. Accordingly, in 1914, he came to Pittsburgh with The Blast Furnace and Steel Plant—then only a tiny pamphlet—and became associated with the National Iron and Steel Publishing Company. Here his strong individuality soon made itself felt. His exceptional ability and his remarkable talent for organization were speedily recognized, and within a few months he was made president of the company. One of the doubtful assets of the company was a weekly journal, rather broad in scope and without distinct appeal to any one definite industry. This was discontinued and in its place appeared The American Drop Forger, which in January, 1921, became Forging and Heat Treating.

The success of these two journals paved the way for a third venture, in the field of coal mining, and in January, 1918, after a careful analysis of the field and the effecting of the necessary alliances, The Coal Industry began publication; thus establishing three publications which effectively serve the interests of the operating officials of three distinct industries.

During the dark days of the World War, Mr. Andresen became very anxious to offer his services to his country. F. C. Andresen, then in charge of the New York office of the National Iron and Steel Publishing Company, was elected Vice President and General Manager, and called to take charge of the business.

Mr. H. A. Andresen tendered his services to the government, and almost immediately was made labor administrator for the Emergency Fleet Corporation. To this work he gave his undivided attention, displaying the energy and constructive ability which characterized all his undertakings.

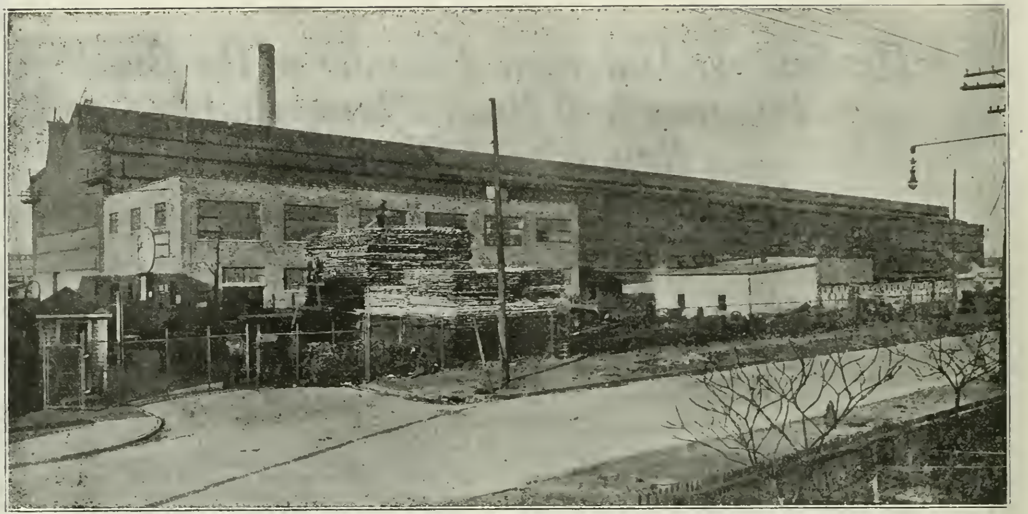
After the war, Mr. Andresen did not return to active participation in his publishing interests. He contemplated a wider field of endeavor.

Acting on this conviction, he first visited the important industrial centers of the United States, and then spent some two years in a tour of the world. His experiences on this trip confirmed many of his former views and fortified him with a varied and extensive knowledge of foreign trade conditions. He returned to America convinced that the greatest commercial possibilities lay in Latin America and the Far East.

While abroad, he appointed capable correspondents in the various countries visited, and he was actively engaged in perfecting the details of a new publishing enterprise.

The publishing projects which he established might well constitute an adequate monument to the lifelong labors of one man, but he looked upon this work as a mere beginning. Still a young man, he had outlined activities of international scope in comparison with which his earlier achievements would have seemed insignificant. In his untimely death the community is prematurely deprived of a brilliant personality and an able citizen, and his many friends have sustained an irreparable loss.

On January 25, 1911, Mr. Andresen was married to Louise S. Tackels, of Detroit. She survives him, with one son, both parents, and a brother, F. C. Andresen, who now succeeds him as President and General Manager of The Andresen Company, Inc., formerly the National Iron and Steel Publishing Company.



Forge Plant for 75 MM Projectiles

Example of Rapid Construction Under Adverse Condition—The Hydraulic Pressed Steel Company, Cleveland, O., Built at the Outbreak of the War, Is Well Designed and Equipped.

By T. W. TOWLER.

IN 1917, shortly after the United States went to war the Hydraulic Pressed Steel Company, which during the preceding two years had been furnishing shell forgings to both the Russian and the British governments, was authorized by the United States government to erect and equip a new forge shop of sufficient size to turn out from 50,000 to 55,000 shell-forgings daily.

The contract for the building and the equipment was awarded on November 10 with the understanding that the production of shell forgings at the earliest possible moment was the "essence of the agreement."

The following day, Sunday, November 11, work on the site was commenced, and on Monday a steam shovel and teams were excavating for the pump pit and foundations. The first steel was erected December 21 and the last structural members were hoisted into place January 26, 1918, the 900 tons of steel having been erected with zero temperatures during the entire period.

The first pair of shells was forged on section No. 1, January 23, a temporary end wall having been erected between sections 1 and 2 to prevent the apparatus from freezing. The succeeding four sections were put in commission at intervals of two or three weeks, the temporary end wall being moved backwards to the north so as to include sections 2 and 3 as soon as they were ready for water and production of forgings. Shortly after section 3 was put in operation, the construction of the shop was so far completed as to render the further use of the temporary wall unnecessary.

By May 1 the plant was turning out on an average 45,000 to 50,000 shells daily and as the crews became more expert, the output was later increased to between 60,000 and 70,000 shells per day. This speedy completion of the project was the result of the most hearty coöperation of the entire Hydraulic Pressed Steel organization led by George C. Brainard, General Manager, and F. H. Smith, Chief Engineer, whose counsel and assistance was always available at any time of day or night.

The enthusiasm shown by the steel erectors, the masons and pipe fitters' organizations in Cleveland is also worthy of mention since the erection of the entire building and its equipment was carried on continuously under most unfavorable weather conditions and with temperatures seldom above the zero mark.

Arrangement of Plant as Shown in Fig. 1.

The departments and details of construction consisted in general of:

The forge shop	80x600 ft.
Two-story office building	56x120 ft.
Boiler house	50x100 ft.
Substation	50x 50 ft.

Miscellaneous small structures, together with a storage yard with about 2500 ft. of track served by a 10-ton traveling crane, 80 ft. span and travel of about 400 ft.

The natural contour of the site, lying as it does on the crest of a side hill, and its location in relation to the old plant and tracks, necessitated raising the grade of approximately half the entire area about 6 feet and the building of a retaining wall 15 feet high and about 1700 feet in length along the north and westerly boundaries. The westerly section of this wall carried the west towers and runway for the 10-ton yard crane.

The 600 foot forge shop built parallel to and directly east of the three receiving and shipping tracks which run

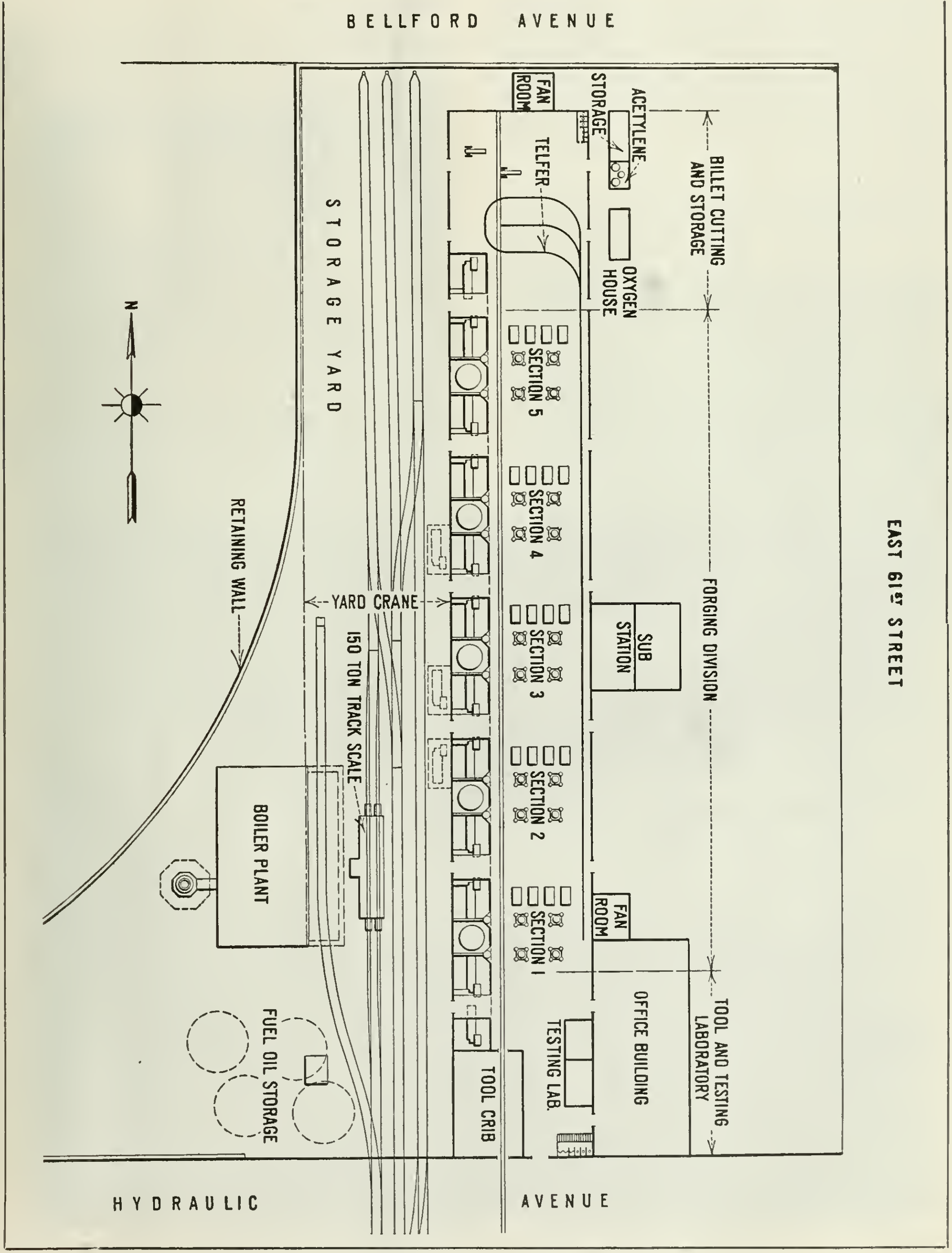


Fig. 2—Airplane view of modern hydraulic pressed steel plant

almost due north and south was divided into three divisions or departments by imaginary lines, the north division, about 80x100 feet, taking care of the billet cutting plant and billet storage, the center division, 80x430 feet was occupied by the forging department proper, consisting of oil fired furnaces, hydraulic forging presses with pumps and accumulators and inspection floors while the southerly division, 70 feet long, was given over to the tool department, testing laboratory and timekeeper's offices.

The building, a steel frame structure with side walls about 80 per cent glass, about 20 per cent removable corrugated-iron panels, and a roof with generous saw tooth monitors, providing for an abundance of light and ventilation, is served its entire length by a 10-ton high speed travelling crane, and is heated by an indirect system with the distributing ducts carried through the roof trusses, drops being installed at each column and outlets located about 8 feet above the floor line.

In view of the exceptionally heavy service, the floors at the front of the furnaces and around the forging presses were of heavy cast iron plates set in concrete while, as a precautionary measure, sand and cinders were used under the furnaces and for cooling beds.

The remainder of the shop floor was of 3 inch wood block laid in pitch on a concrete slab.

Routing of Material.

In general, the routing of material through the shop, from the cutting of bar stock into billets, to the loading of the finished and inspected shell forgings into railroad cars was one continuous forward movement, the bar stock being transferred from cars to the inclined receiving tables at the northwest corner of the shop.

The bars traveling by gravity to the lower end of the receiving table were fed one by one to the cutting tables where they were nicked at proper intervals with acetylene torches and were then fed by hand over roller conveyors to heavy machines which broke the bars previously nicked into billets of the correct length for forging into shells.

The billets were collected at the south side of the breakers in heavy steel skips and were deliverd by an electrically operated monorail hoist either direct to the heating furnaces or temporarily deposited in the billet storage which lay about midway between the breakers and forging department.

The 10 forging units, each unit consisting of a pair of continuous heating type of oil fired furnaces and one 350 ton piercing and one 250 ton drawing press were arranged in five groups or sections. Each section was served by three 250 gallon motor-driven pressure pumps and one 21 inch by 15 foot stroke accumulator loaded to maintain

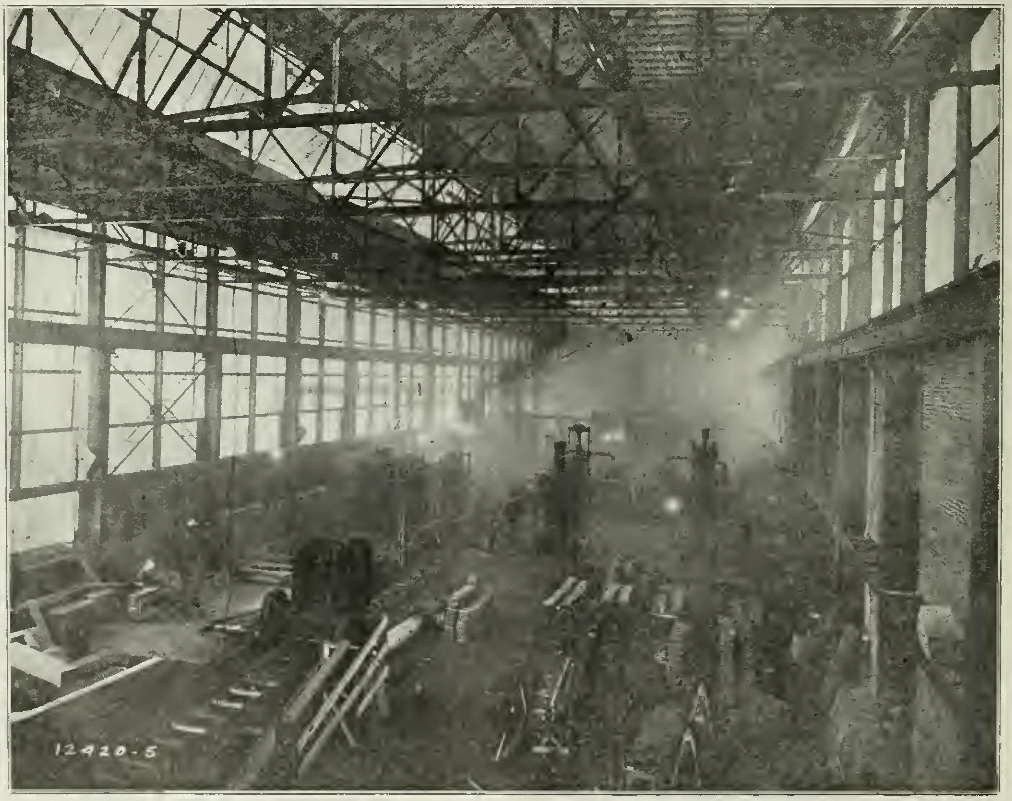


Fig. 3—Interior view of forge shop of the Hydraulic Pressed Steel Company.

a pressure of 1,500 pounds per square inch on the press rams.

Both the piercing and the drawing presses were tooled to work two forgings at each hit or stroke and were so piped that a little better than two strokes per minute could be maintained continuously.

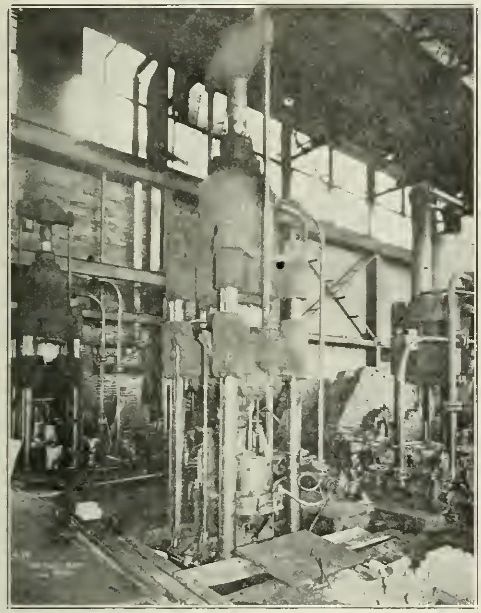


Fig. 4—Piercing Press, first operation.

The Making of a Projectile.

In the making of a shell at this plant the bars (approximately 3 inches in diameter and about 12 feet in length as received) from the mill were first cut into billets varying in length from about 6 inches for shrapnel to as much as 10 inches for a mark IV common shell.

The billets after being brought to forging temperature are placed in the "pot" of the first operation press which by means of a water cooled punch pierces the billet for about 70 per cent of its original length.

Due to the restraining influence of the pot, the metal displaced in the piercing operation, instead of spreading laterally, flows backwards along the punch increasing the length of the forging by from 3 to 4 inches. On the return stroke of the press the pierced shell is lifted part way from the pot by a mechanical "knock out" and at the proper moment is grasped by an operator with suitable tongs and passed quickly to the drawing press for the final passes.

The first of these final operations increases the depth and contour of the interior of the shell and also gives a uniform thickness of metal at the base of the forging.

These operations are performed by means of a hand operated stopper plate held in position directly over the final sizing or drawing dies the press ram of course making only a portion of its full stroke. The almost complete forging is then pushed clear through the sizing dies and there held while the press ram and its punches are withdrawn, leaving the completed shell in a favorable position to be transferred by hand to the cooling floor.

Inspection.

The completed shell forgings were subjected to rigid tests for correct diameters inside and out, concentricity of bore with outside wall, thickness of head or base and over all length.

The inspection of the output of each section was performed in that section and the accepted forgings were transferred direct from the gauging tables to the railroad cars by means of a small motor-driven chain belt, elevators and gravity conveyors.

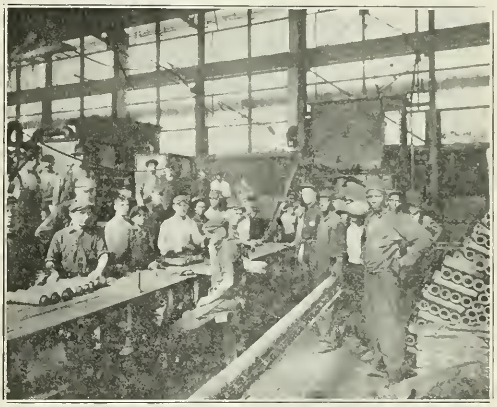


Fig. 5—Inspection, continuous conveyor system shown in foreground.

The photographic reproduction of the shop layout shows clearly the location of the cutting, heating and forging divisions also the location of pumping equipment in relation to storage yard and shipping tracks. Approximately half of all the 75 mm shells forged in the United States during the war were made in this shop and a big percentage of the output was used by the United States troops at the front prior to the armistice.

The last shells were forged December 24, 1919, and the shop is now engaged in the fabrication of light structural steel building frames, this change in character of work having been provided in the general design.

The shop was designed and constructed by Westinghouse, Church, Kerr & Co., Inc., which recently consolidated with Dwight P. Robinson & Co., Inc., under the name of the latter company.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA BANQUET.

Repeal of the excess profits tax, the backbone of the revenue act of October 3, 1917, as well as revision of the present income tax were recommended by C. B. Hurrey, of Washington, chief speaker at the forty-first annual banquet of the Engineers' Society of Western Pennsylvania, held at the William Penn hotel. Approximately 750 of the members of the organization were in attendance of a total membership of over 1200. Mr. Hurrey formerly was deputy commissioner of internal revenue under Daniel C. Roper.

Steel Plants Order Electrical Equipment

General Electric Company Have Received Orders for Special Electrical Apparatus.

DURING the year improvement was shown in approximately every branch of the electrical field pertaining to steel mill operations. Larger equipment was built than ever before, and as a result there were practically no installations of the year that were not watched very carefully by the operating officials of all steel companies. Among some of the interesting equipment built by the General Electric Company, are to be found in the following:

Induction Motors With Modified Scherbius Double Range Speed Regulating Sets.

Illinois Steel Company, Gary, Ind., has ordered two motors to drive a 20-inch hot strip mill. The first motor was rated 5500/440/3400 hp, 170/136/105 rpm, 6600 volts, 25 cycles. This motor was provided with a speed regulating set having 1100 kv-a regulating motor. This is the largest capacity alternating current commutator machine ever built. The second motor for driving this 20-inch hot strip mill was rated at 2070/1650/1205 hp, 235/187½/137 rpm, 6600 volts, 25 cycles.

This order also covered four motors for driving a 12-inch hot strip mill, rated as follows:

Motor No. 1—2756/2240/1750 hp., 262/214/167 rpm.
Motor No. 2—750/625/460 hp., 360/300/220 rpm.
Motor No. 3—750/600/440 hp., 473/375/278 rpm.
Motor No. 4—300/225/165 hp., 335/225/165 rpm.

14-Inch Hot Strip Mill, Trumbull Steel Company, Warren, Ohio.

This mill will consist of 10 stands, all driven by adjustable speed direct current motors, receiving power from two 2200 kw synchronous motor generator sets.

The arrangement of the mill with respect to the drives, is as follows:

Stand	Horsepower (continuous)	Speed rpm.
1, 2, 3, 4	1250	175 to 350
5, 6	1250	175 to 350
7	800	200 to 400
8	800	231 to 462
9	800	256 to 512
10	800	275 to 550

The control requirements for this mill are most exacting. The several stands of the mill are located close together and the steel is rolled at an unusually high speed, making it necessary to provide for very close adjustment of the speeds and for maintaining these speeds with wide fluctuations in load to prevent the development of loops or stretching the steel between the stands.

American Brass Company.

The equipments for three reversing mills for rolling copper are being built for the American Brass Company. Each mill is driven by a 350 hp continuous, 1000 hp max. momentary, 275/470 rpm reversing type direct current motor, the power for which is supplied from 300 kw synchronous motor generators.

Superior Sheet Steel Company, Canton, Ohio.

At this plant there are two General Electric 24-pole, 1000 hp, 300 rpm, 2200 volt, slip ring induction motors, each driving a sheet mill consisting of four finishing stands, two roughing stands and two cold rolls. The motor is geared to the mill through a Falk gear, having gear ratio 9.7 to 1. The gear unit is provided with two flywheels over hung on the pinion shaft, each 10 feet 6 inches in diameter, and each weighing 25,000 pounds. A magnetic control equipment is provided for starting the motor and effective utilization of the flywheel energy is obtained by a notching back relay. Primary reversing oil immersed contactors are provided so that the motor may be plugged in case it is desired to stop it quickly. Additional resistance is inserted in the rotor circuit when the motor is plugged so that the current drawn from the line will not exceed approximately full load current of the motor.

Eastern Rolling Mill Company, Baltimore, Md.

This plant has two 12-pole, 1500 hp, 250 rpm, 2200 volt, 25 cycle slip ring induction motors. Each motor drives a hot sheet mill consisting of six finishing stands and four roughing stands. The motor is geared to the mill through a gear unit manufactured by the Mesta Machine Company, having a gear ratio of 8 to 1. The gear unit has two flywheels over-hung on the pinion shaft, each 13 feet in diameter, and weighing approximately 38,000 pounds each. Magnetic control equipment is provided and a notching back relay insures effective utilization of the flywheel energy.

The cold rolls are driven by an 8-pole, 800 hp, 375 rpm, 2200 volt, 25 cycle slip ring induction motor, which is geared to the mill through a Falk type F-10 gear unit without flywheels, having gear ratio of 9.1 to 1.

Improvements in Switchboard Electrical Equipment.

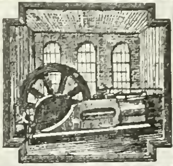
Developments during the past year in switchboard apparatus, which are more especially connected with the control of electrical circuits in the steel industry, are as follows:

Truck Type Panels.

A standard unit safety enclosed removable truck panel consists of a sheet steel panel on which are mounted instruments, meters, oil circuit breakers and other appliances, truck framework to which are attached instrument transformers and disconnecting switch studs suitably mounted on insulators; and the stationary framework with sheet steel compartments for busses and connections and for receiving movable truck.

A switchboard made up of the removable truck type panels can be supplied in separate units or built up to form a complete switchboard with its accessories. Connections are automatically broken as soon as truck is removed from compartment, positively insuring that workmen have no live parts to handle. One great advantage is obtained in that continuity of service is assured. Should a breakdown occur, a spare unit can immediately be placed in service without taking the power off the main bus, thereby interrupting the service on other sections of switchboard; this gives great flexibility to the station.

STEAM POWER DEPARTMENT



Application of Waste Heat Boilers to Open Hearth Furnaces

Detailed Design of the Boilers Showing the Necessity of Superheaters, Soot Blowing Equipment, Feed Water Regulators. Calculations of Waste Heat Boilers for Open Hearth Furnaces.

By THOMAS R. TATE,
Engineer Perin and Marshall.

THE utilization of waste heat from open hearth furnaces is a subject that should appeal to the electrical engineer as well as to the metallurgical engineering profession. The latter are inclined to view it from the aspect of decreased cost per unit of production, while the former should consider it from the standpoint of reduced costs of power or additional capacity available for generating electric current and reduction in investment charges of the coal fired standby station.

Especially for those steel plants which purchase their power is the utilization of waste heat an opportune subject. The public utilities will undoubtedly oppose the installation of waste heat boilers for steam generation as this affects their possibility for the sale of power. Nevertheless, the waste heat boiler installations afford the isolated plant another good and excellent argument for the continuance of its existence.

So many numerous installations of waste heat boilers have been made in this country on open hearth furnaces since the experimental plant constructed at the South Chicago plant of the Illinois Steel Company in 1910, and many tests have been performed and records kept of the daily operation of these installations, that the modern waste heat boiler and theory covering its design have been worked out to such a stage as to insure the ultimate success of almost any installation.

Nearly all of the large steel companies have one or more waste heat boilers in service on their open hearth furnaces today. Some of these were experimental plants and have not given as satisfactory service as an installation made today with the present data available on this subject, would justify. Most of the difficulties have been due to insufficient, or too much draft, lack of proper draft control, improper location of boiler with respect to stack and induced draft fan, and to the presence of numerous air leaks through the checker-work in the waste heat flues and in the boiler setting. All of these troubles can be overcome in new installations, but it is somewhat difficult to obtain the most satisfactory arrangement when a waste heat boiler is added to an existing plant.

The present installations comprise boilers of the fire tube type, horizontal water tube boilers and vertical water tube boilers. Each type has its respective advantages and disadvantages as is the case with standard coal fired practice, and some engineers have their preference, but in many cases the first cost of the installation and the maintenance charges determine the decision as to which type shall be employed; and the question of efficiency and per cent of rating developed is not always given the careful study it deserves.

The results obtained from numerous tests lead to the following conclusions and theories with regard to the waste heat boiler, as applied to the open hearth furnace.

Design.

The design of the proper size and type boiler for an installation should be determined upon the bases of the weight of waste heat gases from any given size furnace and the tonnage rating of the furnace. This weight can be calculated from the amount of carbon content in the fuel and in the charge per ton of ingot steel produced and from analyses of the gases and their atomic weights. The averages of several tests with produced gas show values of CO_2 of from 12 to 16 per cent and of CO from zero to 0.6 per cent.

The draft on the furnace generally varies from 1.3 to 1.5 inches of water. The draft loss through the waste heat flues depends to a great extent upon the length of the flues, number of bends, etc., but for average conditions and a gas velocity of 25 feet per second 0.1 inch of water should suffice. The draft loss through the boiler varies from 1½ to 3 inches of water, depending upon the type of boiler and the area of the gas passage and accumulation of dust on heating surface.

The induced draft fan should be of sufficient capacity to handle the volume of gases passing through it and furnish the desired draft. The method of driving the fan will be discussed later.

The temperature of the gases entering the boiler ranges from as low as 900 degrees F. in some instal-

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Note—Presented before the Philadelphia Section of the Association of Iron and Steel Electrical Engineers, May 1, 1920. Published along with the discussion in the December issue of that society's proceedings.

lations to a maximum of 1,400 degrees F. and varies considerably during a given heat. With a properly designed flue, and the boiler located within 20 to 30 feet of the checkers, an average temperature of 1,200 degrees F. should be obtained at entrance to the boiler.

Due to the fact that most of the heat transfer from the gases through metal heating surface to water comes from the principal of convection of heat and very little transfer is gained from radiation of heat, close attention must be paid to the principles promoting the efficiency of convection. These principles are general and basic and may be stated as follows:

Close confinement of the gases to the heating surface; long gas travel; ample time for the gases to be in contact with the heating surface; gravity or mechanical cleaning of heating surfaces to insure greatest efficiency, and no possibility for the gases to short circuit the heating surfaces, regardless of velocity.

The location of the boiler should be adjacent to the stack, on center line of the furnace. The fuel used may affect the arrangement slightly as it may eliminate part of the checker-work and vary the location of the waste heat flues.

The waste heat flues should be designed to come directly from the checker work to the boiler, with a by-pass around the boiler and fan and suitable by-pass valve. If underground, these should be protected against heat losses and air leaks by from three to four feet of earth. If overhead, they should consist of a steel pipe with a suitable firebrick lining.

Induced draft is absolutely essential to the success of any scheme of open hearth waste heat utilization. The fan, preferably of the steel plate overhung type, should be so located as to obtain ample draft at all times to move the gases generated through the boiler and minimize the length of passage from outlet to stack.

The fan drive should be determined from the standpoint of draft control and feed water heating. Variable speed motors constant speed squirrel cage induction motors, steam turbine drive or steam engine drive may be used with satisfaction.

With variable speed motors, the speed and draft may be controlled from the melting platform. With constant speed motors it is necessary to use a damper, also controlled from the melting platform. With either a steam turbine or a steam engine, the speed and draft may be varied directly at the fan.

The steam turbine affords the most flexible method of drive and of course gives ample exhaust steam for feed water heating.

Superheaters.

Superheaters are a necessary adjunct of any power house and should not be omitted in any waste heat boiler installation. Their location should be such as to furnish the desired amount of superheat. Whether this be between the first and second passes, parallel to the first pass or located in the boiler entrance, should be determined for any given condition and type of boiler used.

The square feet of heating surface required for superheaters is approximately 10 per cent of the total square feet of boiler heating surface.

Soot Blowing Equipment.

Soot blowers are absolutely essential for the successful operation of any waste heat boiler containing a large amount of dust in the waste heat gases and should be installed regardless of the type of boiler selected. If the heating surfaces are not kept clean the average efficiency and percentage of normal rating obtained will rapidly fall, hence the installation of soot blowers as a prime requisite.

Feed Water Regulators.

It is also advisable to have feed water regulators, but the type selected should be unaffected by temperature changes as conditions very often necessitate locating the waste heat boiler outdoors.

Calculations of Waste Heat Boilers for Open Hearth Furnaces.

There has been evolved from the tests made upon waste heat boilers a simple method for determining the horsepower which can be developed and the proper size boiler to be installed for the development of that horsepower, which is as follows:

$$\text{B.H.P.} = \frac{W \times C \times (T_1 - T_2) \times E}{U \times L}$$

In Which:
B.H.P. = Boiler horsepower.
W = Pounds of gas available per hour.
C = Specific heat of the gases.
T_1 = Initial temperature of the gases entering the boiler.
T_2 = Temperature of the gases leaving the boiler.
E = Constant used to cover unaccountable losses, variation in dust accumulation on heating surface, etc.
U = Pounds of water evaporated from and at 212 degrees F. per hour per bhp.
L = Latent boiler vaporization from and at 212 degrees F.

The coefficient E appears from test results to have a value of between 85 and 90 per cent.

As an approximation W may be assumed on the basis of 1000 pounds of gas per ton of output if operating on producer gas.

The specific heat C may be taken as .24 to .27 for most calculations.

The heating surface required in the boiler to develop the horsepower obtained by the following formula:

$$S = \frac{W \times C \times (T_1 - T_2)}{R \times \left(\frac{T_1 + T_2}{2} - \frac{t_1 + t_2}{2}\right)}$$

In which:
W, C, T_1, T_2, are the same as above.
R = Rate of heat transfer = B.T.U. per square foot of heating surface per degree temperature difference per hour.
t_1 = Tempreature of steam due to pressure.
t_2 = Temperature of feed water.
S = Square feet of heating surface.

The rate of heat transfer can be calculated or interpolated from a curve (See "Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface," by the B. & W. Co.), provided gas passage area of the boiler is known in terms of weight of gases per square foot of flue area per hour. In open hearth waste heat boilers of the horizontal water tube type, this gas area is restricted to approximately 3,500 pounds per square foot of gas passage area per hour, and a high gas velocity thereby obtained.

Interpretation of Flue Gas Analysis

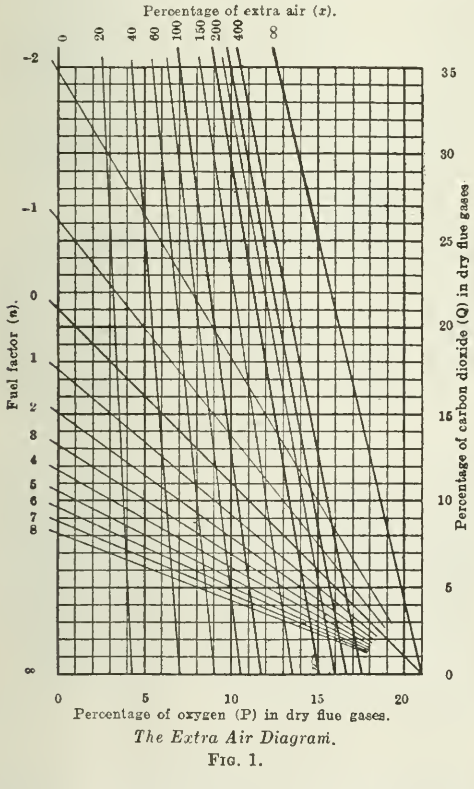
A New Graphical Method for the Interpretation of Flue Gas Analysis—Graphs Applicable to Practically All Fuels Used in Steel Plants.

By **GILBERT B. HOWARTH,**
The University—Leeds, England.

COMPLETE tests of the thermal efficiency of boilers, furnaces, and similar appliances generally involve a series of laborious calculations intended to determine:

1. The ratio of the amount of air supplied for combustion to the minimum amount of air theoretically required for complete combustion, and
2. The ratio of the amount of heat in the hot flue gases to the amount of heat liberated by the combustion of the fuel.

If these calculations can be generalized in such a way that the results may be represented on a system of coördinates, the determinations may be effected rapidly from the smallest possible number of experimental data.



The Extra Air Diagram.
FIG. 1.

The combustion with excess of air of any fuel containing only carbon, hydrogen, oxygen, and nitrogen may usually be regarded as producing flue gases composed of mixture of carbon dioxide, water vapor, oxygen, and nitrogen. In the usual processes of gas analysis water is eliminated and the composition of the dry gas obtained. The ratio of the volume of water vapor in the flue gases to the volume of carbon dioxide is equal to half the ratio of hydrogen atoms to carbon atoms in the fuel.

The composition of the dry flue gases may be completely defined by a statement of the percentages of any two of the dry constituents (say oxygen and carbon dioxide), the percentage of the third (in this case nitrogen) being obtained, if required, by difference. These quantitis may be calculated for the combustion of any given fuel with any given percentage excess of air by constructing a chemical equation. Thus there are four variable quantities:

P = Percentage of oxygen in the dry flue gases.

Q = Percentage of carbon dioxide in the dry flue gases.

x = Extra air, expressed as a percentage of the minimum quantity of air theoretically required for complete combustion.

n = A quantity depending on and to be calculated from the composition of a fuel, and which is the same for those fuels (and no others) which, when burnt with a given percentage of extra air, give flue gases of the same dry composition.

From any given values of n and x it is possible to construct a chemical equation, and from it to calculate corresponding values of P and Q.

Suppose that the values of P and Q calculated for a number of values of n and x are plotted on a system of rectangular coördinates and that lines are drawn through all points obtained from the same value of n, and another series of lines through all points obtained from the same values of x. The two series of lines thus drawn will constitute an irregular grid superimposed on the original rectangular grid. This double grid constitutes the basis of the "graphical method" to be described in this paper. It will be seen that for any point on the diagram the four quantities, P, Q, n, and x may be read off at once on two grids. Moreover, any two of the four quantities are sufficient to define a point on the diagram from which the other two quantities may be obtained at once by inspection.

The commonest use of the diagram for industrial purposes is the following: The "fuel factor" (n) being known from the composition of the fuel, the only observation required is the percentage of carbon dioxide in the dry flue gases in order to obtain accurately from the diagram the percentage of oxygen in the dry flue gases and the percentage of extra air. Moreover, if the composition of the fuel is not known, the value of n can be found from the diagram by a single determination of carbon dioxide and oxygen in the dry flue gases.

The calculation of the coördinates of multitude of points from a corresponding number of chemical equations (as supposed in the preceding paragraphs) is not

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Paper presented before Society of Chemical Industry and Published in Their Journal.

actually required in practice. The chemical equation representing the combustion of $C_a H_b$ with x % of extra air containing A % of oxygen is the following:

$$C_a H_b + (a + b/4 [O_2 + (100/A - 1) N_2] +$$
$$0.01 x (a + b/4) [O_2 + (100/A - 1) N_2] =$$
$$a CO_2 + b/2 H_2O + 0.01 x (a + b/4) O_2 +$$
$$(1 + 0.01 x) (a + b/4) (100/A - 1) N_2$$

From this it is seen that

$1+0.01x(1+b/4a)+(1+0.01x) (1+b/4a) (100/A-1)$ volumes of dry flue gases contain volumes of CO_2 and $0.01 x (a + b/4)$ volumes of O_2

$$\frac{x (+ b/4 a)}{1+0.01x(1+b/4a)+(1+0.01x) (1+b/4a) (100/A-1)}$$

and percentage of carbon dioxide = Q =

$$\frac{100}{1+0.01x(1+b/4a)+(1+0.01x) (1+b/4a) (100/A-1)}$$

Since the values of P and Q for a given value of x depend only on the ratio b/a, we may accept this ratio as fulfilling the function of the quantity n mentioned above. Hence we may put n = b/a. Then if A= 21.0, from these two expressions, by the elimination of x, the following general equation for the "fuel lines" is obtained:—

$$P + (1 + 0.1975n) Q = 21.0$$

which is the general equation of a series of straight lines (one for every value of n), all of which pass through the point (21.0).

By the elimination of n from the same expressions, the following general equation for the "extra air lines" is obtained:—

$$(376/x + 4.76) P + Q = 100$$

which is the general equation of a series of straight lines (one for every value of x), all of which pass through the point (0,100).

These results, shown graphically in the extra air diagram (Fig. 1), are quite in accord with the disposition of the lines that might be expected from general considerations.

It should be noted that when P = 0 (i.e., complete combustion without excess of air) the equation of the fuel lines becomes

$$Q = 21.0/(1 + 0.1975n)$$

thus giving the percentage of carbon dioxide obtainable in such ideal conditions.

It has been shown above that any hydrocarbon may be completely defined for the present purpose by the ratio of the number of atoms of hydrogen to the number of atoms of carbon accompanying them, i.e., n= H/C. Thus, for example, n is 1 for benzene or acetylene, 2 for olefines, 2.4 for pentane.

Other methods of defining hydrocarbons (e.g., by the gravimetric percentage of one of the elements, etc.) may be used, provided that the numbers attached to the fuel lines on the "Extra air diagram" are amended accordingly.

It is evident that the addition to or removal from a fuel of oxygen and hydrogen in the proportion to form water will have no influence whatever on the composition of dry flue gases. Thus, to obtain n we must subtract from the number of atoms of hydrogen two atoms of hydrogen for every atom of oxygen in the fuel and divide the remaining number by the number of atoms of carbon, i.e., n = (H — 2O)/C. Where a fuel is rich in oxygen, the value of n thus obtained may be negative; thus for carbon monoxide n = — 2, and for carbon dioxide n = — 4.

The majority of pure combustibles may be dealt with by the formula n = H — 2O)/C. For example, n is 2 for alcohol or ether, and 0 for carbohydrates.

Nitrogen in the fuel is assumed to be associated with a portion of the oxygen in the proportion to form air. Thus, for example, the products obtainable by the complete combustion of $C_a H_b O_c N_d$ without excess of air will have the same composition as those obtainable by the complete combustion of $C_a H_b O_c - d/_{3.76}$ without excess of air. This suggests that the value of n is the same for both substances and is equal to [b — 2 (c — d/3.76)] /a or, using chemical symbols, n = (H — 2O + 0.532 N) /C. But the minimum quantity of air required for the combustion of a molecule of $C_a H_b O_c N_d$ is a + b/4 — c/2 volumes and for the combustion of a molecule of $C_a H_b O_c -_{d/3.76}$ is a + b/4 — (c — d/3.76)/2 volumes, and any extra air supplied is measured as a percentage of one or other of these two quantities according to the formula used to represent the combustible. Therefore the percentage of extra air given by the chart (which utilizes the second expression) must be converted into the units obtainable by actual measurement (according to the first expression) by multiplying by

(a + b/4 — c/2 + d/7.52) / (a + b/4 + c/2).

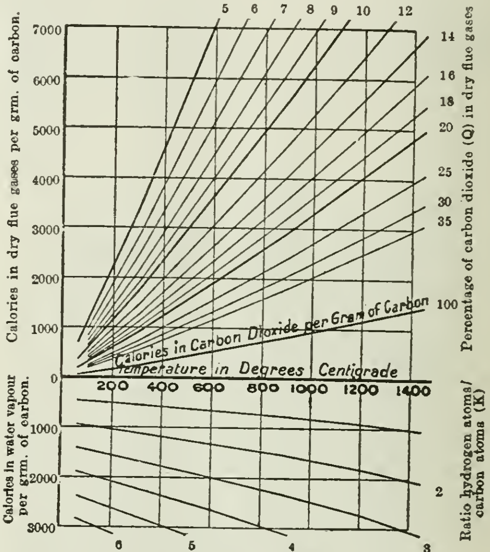
In other words, the chart readings (x) must be increased by a certain fraction, δx/x, viz.,

$$\frac{\delta x}{x} = \frac{d/7.52}{a + b/4 - c/2} = \frac{0.532d}{4a + b - 2c}$$

or, reverting to the use of chemical symbols, the correction to be added to the percentage of extra air given by the chart

$$= \delta x = \frac{0.532N}{4C + H - 2O}.x$$

In the same way, if the percentage of extra air is included in the data, this (x + δx) .must first be reduced to the chart readings (x) by subtracting the following correc-



The Thermal Diagram.

FIG. 2.

tion from the percentage of extra air as given:—

$$\delta x = \frac{0.532N}{4C + H - 2O + 0.532N} \cdot (x + \delta x)$$

For many industrial purposes (for example, routine tests to regulate the supply of secondary air to a gas-fired furnace) absolute values of the extra air are not essential, and relative values are almost as useful in controlling the approach to the theoretical minimum. In this case the correction δx need not be applied, the figures obtained being regarded as relatively correct. The errors thus introduced become smaller as the theoretical minimum of air is approached. Or an approximation may be made by using a simple empirical formula applicable to a given class of fuel.

An alternative method of dealing with nitrogen is based on the fact that the addition of nitrogen to a fuel reduces the proportions of oxygen and carbon dioxide in the flue gases in the same proportion. Though this treatment is not usually convenient in practice, it provides an interesting confirmation of the arguments used above and a simple method of verifying the accuracy with which the diagram is drawn.

We may consider that the combustible sulphur in the fuel burns completely to sulphur dioxide. Atoms of sulphur should be added to atoms of carbon, the SO_2 being recorded as CO_2 in the flue gas analysis. The molecular ratio of the two gases will evidently be the same as the atomic ratio of the elements. In practice the proportion of sulphur in the fuel is usually small, and the presence of this element may be ignored, or its quantity assumed to have a suitable average value for all fuels of a given type.

The above formula deal with the atomic composition of the fuel. It will be clear that they may be adapted to suit gravimetric composition, or, in the case of gases, volumetric composition. These formulae are summarized in Table 1.

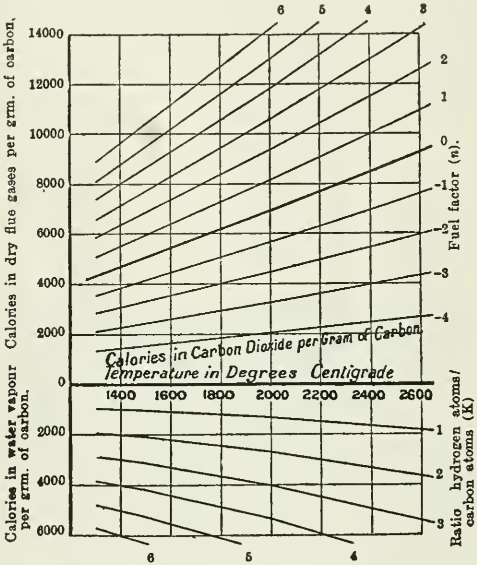
The part of the "Extra air diagram" above and to the right of the line corresponding to $n = -4$ and $x = \infty$, and the part below the P-axis ($n = \infty$) do not appear to be applicable to ordinary industrial fuels.

The region to the left of the Q-axis involves negative values for the extra air and oxygen. Evidently this area covers the important case of incomplete combustion, where the negative percentage of extra air implies a deficiency of air and the negative percentage of oxygen implies the presence of an equivalent quantity of unconsumed combustibles. It seems possible that this region might be utilized by considering separately the fuel factor of the fuel burnt, and the fuel factor of the combustible material remaining in the flue gases. But the process becomes very complex when combustion is seriously incomplete.

For any physical properties of the dry flue gases that may be calculated from their composition (e.g., density, heat capacity over any stated range of temperature, etc.) further series of lines may be drawn on the "Extra air diagram." The determination of carbon dioxide in the dry flue gases may then be replaced by a determination of any physical property for which curves have been prepared. In practice it may be more convenient to make the measurements on the flue gases saturated with water vapor at a pre-arranged temperature, this modification being taken into account in the calculation of the curves to be superimposed on the extra air diagram.

The author has no difficulty in using an extra air diagram photographically reduced from the original large and complex diagram to a size of about 2 in. x 3½ in. For industrial purposes it is suggested that a diagram about 30 in. x 18 in. with many more lines should be reproduced by lithography in a single color to avoid registration troubles). From such a diagram, suitably mounted on sheet, zinc, or three-ply board, any draughtsman could trace the lines in distinct colors, the tracing being confined to that part of the diagram that was of particular interest for the purpose in view.

The composition of the dry flue gases being known, either by actual analysis or by the use of the diagram already described, the thermal capacity of the dry flue gases over any given range of temperature may be calculated from the mean specific heats at constant pressure of the various constituents over the given range.



The Flame Temperature Diagram.
FIG. 3.

From the large number of specific heat determinations that have been made the calorimetric measurements up to 1400 degrees C. carried out by Holborn and Henning may be selected. Their results are so arranged as to give for each gas the mean specific heat at constant pressure from 0 degrees C. to t degrees C. in the form of a linear or quadratic expression in t. (For water vapor 100 degrees C. forms the lower limit). Since oxygen and nitrogen have practically the same molecular specific heats, Q and t are the only data required for the calculation of the heat contained in a given amount of the dry flue gases. Moreover, since the weight of carbon burnt in the formation of this quantity of dry flue gas can easily be found, the quantity of heat in the dry flue gases formed during the combustion of unit weight of carbon may be obtained. The equation connecting this quantity with Q and t is the general equation of the curves forming the upper part of the "Thermal diagram," (Fig. 2). It will be recognized that, of this quantity of heat per gram of carbon, the quantity of heat per gram of carbon contained in the carbon dioxide alone is given by the curve corresponding to Q = 100.

The lower part of the thermal diagram shows the total heat (sensible plus latent) contained in the water vapor accompanying the above quantity of dry flue gases. For any given temperature this may be expressed in terms of K, which is the ratio of hydrogen, atoms to carbon atoms in the fuel burnt. Evidently the total heat in the whole flue gases per gram of carbon burnt is the sum of these two quantities (i.e., for dry flue gases and for water vapor), and is obtained by measuring along the ordinate corresponding to the observed temperature the intercept between the curve corresponding to Q (the percentage of carbon dioxide in the dry flue gases) and that corresponding to K (the ratio of hydrogen atoms to carbon atoms in the fuel burnt).

According to Holborn and Henning the mean specific heat at constant pressure from 0 degrees C. to t degrees C. (in calories per gram) are as follows:

N_2 $0.2350+0.000019t$
CO_2, $0.2010+0.0000742t-0.000000018t^2$
H_2O (from 100° C.) $0.4669-0.0000168t+0.000000044t^2$

Calculation from these gives:

Heat in dry flue gases per gram of carbon burnt $= (54.83t + 0.00443t^2) / Q + 0.189t + 0.000228t^2 - 0.000000066t^3$ from which the upper part of the thermal diagram may be plotted. Also total heat in water vapor produced during the combustion of 1 g. of carbon

$= K(445.0 + 0.3515t - 0.0000159t^2 + 0.000000033t^3)$ from which the lower part of the thermal diagram may be plotted.

Table 3—Values of n, $\delta x/x$, and K for Various Gaseous Industrial Fuels.

	American carbureted water gas	Coal gas, horizontal retorts	Coal gas, vertical retorts	Debenzolized coke oven gas	Present day town's gas	Blue water gas	Producer gas (bituminous coal —no steam)	Mond gas	Blast furnace gas
Cal. val. Btu per cu. ft	713	625	587	526	480	316	155	152	106
CO_2	3.0	2.5	2.5	2.5	4.0	4.5	1.0	17.0	10.0
CO	27.0	5.5	10.0	6.5	12.0	43.0	29.0	11.0	30.0
C_3H_6*	12.5	3.5	3.5	2.0	1.0	..	..	..	..
CH_4	19.5	33.0	27.0	25.0	28.0	0.5	2.0	3.0	..
H_2	30.5	49.0	52.0	55.0	34.0	48.0	10.0	24.0	1.0
O_2	1 0	0.5	0.5	0.5	1.0	..	..	..	..
N_2	6.5	6.0	4.5	8.5	20.0	4.0	58.0	45.0	59.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
n	1.73	4.55	4.12	5.15	3.48	0.21	0.87	0.58	—0.88
$\delta x/x$	1.40%	1.47%	1.19%	2.53%	6.44%	2.25%	65.7 %	50.9 %	101.5 %
Approx.†	1.37%	1.44%	1.15%	2.42%	6.25%	2.22%	65.5 %	51.8 %	97.5 %
K	2.46	4.88	4.66	5.55	3.96	2.04	0.88	0.52	0.05

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*C_3H_6 is the assumed average composition of the unsaturated hydrocarbons. †Using the formulae given in Table 1.

The expression "Theoretical flame temperature," is often used to denote that temperature at which, when a fuel is burnt with the minimum quantity of air, the heat in the flue gases is equal to the heat developed by the combustion of the fuel. Occasionally a specified fraction of the heat developed by combustion is employed, in order to allow for radiation losses from the flame. Evidently this temperature may be found by means of a thermal diagram resembling that already described. However, in general the "theoretical flame temperature" of industrial fuels lies between 1500 degrees C. and 2500 degrees C. —beyond the scope of Holborn and Henning's specific heat determinations. The most convenient data to use are those collated by Lewis and Randall (J. Amer. Chem. Soc., September, 1912), who modified a large variety of experimental results to agree with theoretical requirements, thus obtaining simple formula likely to be reasonably accurate over a wide range of temperature, certainly up to 2000 degrees C.

As in this case the fuel is always supposed to be burnt with the theoretical minimum quantity of air, we may substitute for Q the value given previously — when $P = 0$, $Q = 21.0/(1 + 0.1975n)$, so that the lines in the upper part of the diagram may be labeled with values of n instead of with values of Q. Then, n and K being known from the analysis of the fuel, and the calorific value of the fuel per gram of carbon being obtained, the "theoretical flame temperature" may be read from the diagram (Fig. 3).

As before, the heat contained in the carbon dioxide alone is given by the curve corresponding to $n = -4$.

According to Lewis and Randall the specific heats at constant pressure at T degrees C. absolute (in calories per g.—mol.) are as follows:

N_2 and O_2 $6.5 + 0.0010T$
CO_2 $7.0 + 0.0071T - 0.00000186T^2$
H_2O $8.81 - 0.0019T + 0.00000222T^2$

Calculation from these gives:

Heat in dry flue gases per gram of carbon burnt $= n(0.531t + 0.0000392t^2) + 2.854t + 0.000411t^2 - 0.000000052t^3$ from which the upper part of the flame temperature diagram may be plotted.

Also total heat in water vapor produced during the combustion of 1 g. of carbon $= K(445.0 + 0.3523t - 0.00001458t^2 + 0.000000308t^3)$ from which the lower part of the flame temperature diagram may be plotted.

Table 1—Summarized Formulae.

From atomic composition.
$n = (H - 2\ O + 0.532N)/(C + S)$
$\delta x = 53.2N/\ [4\ (C + S) + H - 2\ O]\%$
$K = H/C$

From gravimetric composition.
$n = (4H - \frac{1}{2}\ O + 0.152N)/(1/3\ C + \frac{1}{8}S)$
$\delta x/x = 15.2N/[4(1/3C + \frac{1}{8}S) + 4H - \frac{1}{2}O]\%$
$K = 12H/C$

From volumetric composition of gases.*
$n = [6C_3H_6 + 4\{CH_4 - (CO_2 + O_2)\} + 2(H_2S$

(Continued on page 181)

Heating Furnace Fuel Progress During 1920

All Manufacturers Are Interested in the Present Fuel Situation and Are at Present Laying Plans for Economizing Their Fuel Costs—The Proper Fuel for Furnaces Should Be Selected.

By A. E. BLAKE.

THE first nine months of 1920 witnessed feverish manufacturing activity, during which there was a continued uncertainty in regard to the fuel supply. This uncertainty gradually disappeared in the last quarter of the year; but as the coal situation became more favorable, the status of natural gas has become more uncomfortable and discouraging than at any time heretofore.

The use of fuel oil in competition with coal or gas is largely dependent upon its price, and that has reached levels such as to greatly discourage its use. The price receded somewhat in the latter part of the year, but there seems to be little hope that it will fall to the levels reached in the summer of 1919 or of the prewar period.

In a monograph entitled "The Petroleum Outlook," published in 1920, by Arthur D. Little, Inc., Chemical Engineers, Cambridge, Mass., we find the following: "The oil industry, in short, is face to face with the issues of its remarkable career. In making the most of its opportunity for expansion, it has assumed economic responsibilities far in excess of what it can hope to meet. Some of these, the less essential, it must now get out from under in order to go on meeting the other and more essential ones."

To those who have had to do with the purchase and use of fuels, the factors which had bearing upon the fuel supply and prices are familiar enough to require no comment. It is the writer's object to show in general, some of the possibilities which have become apparent to those who have had serious fuel problems and have solved them to some more or less satisfactory degree. While it may seem to many as thought the times are, and have been, very unfortunate as regards fuel supply, they are turning out to be a blessing in disguise, because of the enforced abandonment of crude methods.

Manufacturers are continually on the lookout for new sources and kinds of fuel, but they still have much progress to make in methods of application. Not that these methods are by no means unknown, but because of the general distrust of new methods which exist among furnace operators. Throughout the whole situation, one in touch with the facts cannot fail to be impressed at the surprising lack of technical men who are capable of rendering unquestionable decisions in regard to fuel selection and utilization. The writer believes that the fuel question cannot fail to increase in importance and that it is one worthy of the best trained engineering talent. It also seems clear that the best solutions are to be achieved when full recognition is had of the relation of the science of chemistry to the subject. It is evident today that the chemist and chemical engineer have thus far overlooked a very fertile field and one which with proper study would yield more return to them and to the public than any other.

Owing to the careful attention which has been paid to the subject of gas making equipment, the fuel engineers of our industrial plants now have a remarkably good list of alternatives from which to select heating furnace fuels. Passing over coal firing equipment of various kinds, in which there has been little progress in the past 12 months, and oil firing equipment of which the same is also true, so far as the writer is aware, we come to the subject of advances in the production and utilization of gaseous fields.

Producer Gas.

The use of raw hot producer gas is surely coming to be recognized as having a more limited field for industrial heating than many of those who advocate its use are willing to admit. In steel mill work, beyond its use as fuel for open hearts, soaking pits, and batteries of very large slab, billet, skelp, tube, and other recuperative or regenerative furnaces there is no difficulty in finding a more suitable gas, and in works where coke oven gas is available, the above named installations are generally heated with it in preference to producer gas. The elimination of various nests of producers from the production area of a mill and the freeing of the transportation system from the duty of coal carrying, and the elimination of massive brick lined gas mains requiring frequent cleaning out, are factors in the preference for better gas.

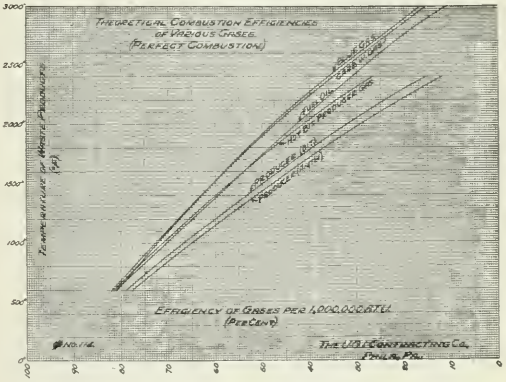

Fig. 1.

For several low temperature operations, cold cleaned producer gas, generated and cleaned at a central plant, has received considerable attention. For mold drying, core baking, soft metal melting, tinning and galvanizing, such gas has much to recommend it, since it will do the work perfectly, and eliminate the labor and expenses incident to the use of coal or coke. Producers for making this type of gas can be purchased with such low rated capacity, and at such a price, that even a small bake shop need not depend upon natural gas any longer. It seems likely that there will be much activity in the further use of this fuel, particularly as the methods multiply for cleaning it adequately. Very few good cleaning systems for bituminous producer gas are known at present.

The use of producer gas in extensive plants, even for low temperature work is really unsound, as the following may help to make clear. It will be recalled that producer gas contains approximately 60 per cent nitrogen, which acts as the diluent in the matter of increasing the combustion volume and thus decreases the combustion intensity. A theoretical mixture of 150 Btu producer gas which requires about 1.3 cubic feet of air per cubic foot, has a heating value of only about 65 Btu per cubic foot. This value is about 65 per cent of those for natural gas, coke oven gas, water gas, etc. The reaction temperatures theoretically adaptable is only about 2,500 degrees F. This value is about 1,000 degrees lower than for the other gases just mentioned, hence the nearer the furnace temperature requirements are to the reaction temperature of producer gas, the greater the drop in efficiency of fuel consumption. This gas is automatically ruled out for direct firing, as the temperature requirements approach the reaction temperature.

A brief examination of the curves shown in Fig. 1* will illustrate the point just made. It will be found that at a temperature of say 800 degrees F., the heat of combustion passing into the flue for waste gases is 28.5 per cent of all that is generated, in the case of cold clean producer gas; whereas it is 25.0 per cent for water gas; at 1,600 degrees F., the figures are 56 and 42 per cent; and at 2,000 degrees F., they are 71 and 52 per cent, respectively. Even at the low temperature the steady, unremitting, and unnecessary drain upon the fuel pile should be sufficient to warrant careful thought on the subject of a more expensive type of gas plant. The French name for producer gas is "poor gas", (gaz pauvre) and the French language is noted for its steel-cut precision.

Water Gas.

The adaptability of water gas to industrial heating has been singularly overlooked in this country, and yet its development as a fuel took place in Pennsylvania in the seventies. Its use is common in Europe, however, and several plants in America have adopted it in some degree. Interest in it is growing and wide spread. As a matter of fact, the gas has been under our very noses, so to speak, disguised as carburetted water gas, and used for domestic purposes, and small industrial and commercial heating where natural gas cannot be had. Its standing among fuels, from the efficiency viewpoint is shown by Fig. 1. Its cost of manufacture is only slightly, if any, higher per million Btu's than that of cold clean producer gas. It can be mixed with coal gas to good advantage, and the duplex process, whereby bituminous coal can be made to supply mixed coal gas and water gas of average heat content of 375 Btu per cubic foot, at the rate of 15,000,000 Btu per ton, without question forms the solution of the gas problem for many an industrial plant. This process yields first quality gas from the nearest and most reliable source, bituminous coal, at a cost per heat unit lower than the common rates for natural gas in the Pittsburgh district.

In his discussion of the writer's paper on "Water Gas" proceedings of the Engineers Society of Western Pennsylvania, December, 1920, Mr. J. H. Taussig, Gas Engineer, of the sales department, U. G. I. Contracting Company, Philadelphia, Pa., made the following remarks:

"Blue water gas for industrial uses is not new practice in England and Germany, but it may be considered somewhat new in this country. In Europe where natural gas is lacking and oil is more costly, blue gas has been one of the most important fuels of industrial plants.

In the past, there has been no incentive to go into the manufacture of blue gas apparatus in this country, though we have been manufacturers of carburetted water gas apparatus since 1882. Oil and natural gas have been so cheap and plentiful in this region that water gas seems to have been forgotten. Since the war began, everything has been upset, including prices of fuels, particularly oil and natural gas, and it looks as though they would not be lowered any. We soon realized that water gas would make a splendid substitute.

Where the heating must be non-regenerative, and the gas must be clean for extensive distribution, blue gas is especially good. Producer gas distribution over a large plant requires a tremendous piping system. It has a specific gravity of about 1.00, while blue gas has a specific gravity of only .55. The mixed gas is still lighter. (Mr. Taussig refers to coal gas mixed with water gas as from the duplex process.) At the same line pressure, about four times the number of heat units can be transmitted per given size of pipe of water gas as with producer gas. That is quite an item in a large plant. Blue gas can be used to gain the highest temperature required in gas furnaces without recuperation or regeneration, whereas cold producer gas calls for such practice at temperatures above 1,700 or 1,800 degrees F. Blue gas can also be used on regenerative furnaces, where the work and shop conditions are of such a nature as to permit it. In heat treating work, blue gas furnaces are very much more easily regulated and do not permit scale formation on iron and steel as readily as those fired by raw producer gas.

I would like to emphasize particularly the fact that in the Pittsburgh district, a combination of coke retort plant and blue gas plant will prove to be the cheapest source for artificial industrial gas fuel."

To make 1,000,000 Btu's of mixed gas in a combination plant, with coal at $3.50 per net ton, it would cost about 30 cents, exclusive of investment charges. The investment cost at 12 per cent would make the additional cost 15 cents, making the total cost about 45 cents per 1,000,000 Btu. Is this not an attractive proposition for a fuel that can be used for all purposes with at least as much efficiency as with natural gas?

It might interest you to know that with coal at $3.50, the equal number of heat units in combination gas would be equivalent to 6½-cent oil, while with coal at $5.00 per ton, the gas will compare with 8-cent oil. This includes the investment cost for gas while the price of oil is merely that for its delivery into the storage tanks. Comparisons on the basis of production have shown the ratio between this mixed gas and oil to be $3.50 coal to 3-cent oil, or $5.00 coal and 4-cent oil."

With the exception of large regenerative furnaces, where the equipment is placed in a position almost adjoining the furnace, I do not see any place where producer gas could compete with the combined gas.

(Continued on page 181)

*Courtesy of the U. G. I. Contracting Company, Philadelphia, Pa.

Where you have a gas with a reaction temperature of 3,500 degrees F., you are going to get high efficiency in every type of industrial furnace, whether it requires a low temperature or not."

Other Gases.

It is safe to say that because of conditions, no recorded process for obtaining gas has escaped attention in the past 12 months. Owing to the just aversion for large scale experimentation, however, few are likely to have a trial. An interesting and most ingenious process is being developed for the making of producer gas from oil, and some installations are complete and operating. The main question of its preferment is that of the cost of a 1,000,000 Btu's, however, compared to that for other efficient gases. Furthermore, if the art were more advanced in applying oil fuel direct with the efficiencies which are obtainable with gases, the field for the gasified oil would become quite narrow.

The competition of artificial gas with raw coal is a subject which is just becoming of interest to many steel mill men. It has already been stated that the gas can be delivered, all charges paid, at a cost below that of natural gas at present prices for coal. This factor alone would tempt many to investigate it. During the past year, however, extensive application of modern equipment for firing with gas has been made in steel plants, notably in sheet mill furnace heating. Following is data taken from regular sheet mill operation, showing the extent to which natural gas has been sacrificed in the past, and how erroneous is the common impression that the "blanket of flame" is essential for heating and scale prevention.

Type of installation, multiple chamber sheet furnace. Temperature of operation—about 1,700 degrees F. Number of reheats on the sheets—3 or 4.

No. of Furnace	Vol. of gas used	Wt. of sheets rolled	Cu. ft. of gas per lb.
1	432,200	280,100 lbs.	1.543
2	330,600	271,940 lbs.	1.212
3	969,000	327,620 lbs.	2.958
4	1,102,800	271,600 lbs.	4.060

The average consumption per pound of steel in the case of Nos. 1 and 2 equals 1.3775. These furnaces are heated with the most modern equipment obtainable. The average requirements of the other two furnaces equal 3.509 cubic feet per pound. These furnaces were fired by the so-called lazy flame. The difference in gas consumption per pound equals 2.1315 cubic feet. This is 60 per cent of the amount of gas which has been used up to the time the modern application was discovered. It will be interesting for the reader if he chooses to determine for himself the dollar and cent saving for a continued operation of, say 300 days.

In consideration of such results, it would seem that when going into the consideration of artificial gas, it will pay the mill man to provide modern means for using it, since in the above case it is fair to suppose that the size of installation, and consequently its cost, can be tremendously reduced. It seems worth while to emphasize what has already been referred to in the foregoing as regards the influence of lulls in manufacture. The writer can recall no time when as much interest in the foregoing subjects has been displayed, as is now evidenced by plant engineers, managers and directors. This is exactly as it should be, and we are safe in being assured that the most rigid economy will be required in all phases of manufacture from now on.

INTERPRETATION OF FLUE GAS ANALYSIS.

(Continued from page 178)

$+ H_2 - CO) + 1.064N_2]/(3C_3H_6 + CH_4 + CO + CO_2 + H_2S)$

$\delta x/x = 53.2N_2/(9C_3H_6 + 4CH_4 + 3H_2S + CO + H_2 - 2O_2)\%$

$K = (6C_3H_6 + 4CH_4 + 2H_2 + 2H_2S)/(3C_3H_6 + CH_4 + CO + CO_2$.

Approximations (subject to amendment).

For coals (gravimetric composition).

$\delta x/x = \frac{1}{8}N\%$ but is practically always negligible.

For industrial gases over 400 Btu (gross) per cu. ft.

$\delta x/x = (300 \times N_2)/(2 \times \text{cal. val.})\ \%$

(from volumetric composition).

For industrial gases under 400 Btu (gross) per cu. ft.

$\delta x/x = (700 \times N_2)/(4 \times \text{cal. val.})\ \%$

(from volumetric composition).

Table 2—Values of n, $\delta x/x$ and K for Various Solid Industrial Fuels.

	Lignite	S. Yorks bituminous	S. Wales bituminous	S. Wales steam	S. Wales anthracite	Gas coke
C	59.5	75.9	79.1	87.6	90.4	87.2
H	6.0	5.2	4.5	4.1	3.3	1.2
O	27.3	9.3	6.8	1.2	2.5	2.3
N	0.5	1.3	1.0	2.8	0.9	0.8
S	1.5	2.8	0.9	0.8	0.9	1.2
Ash.	5.2	5.5	7.7	3.5	2.0	7.3
	100.0	100.0	100.0	100.0	100.0	100.0
n	0.52	0.63	0.56	0.55	0.40	0.13
$\delta x/x$	0.08%	0.17%	0.13%	0.32%	0.10%	0.10%
N/8	0.06%	0.16%	0.13%	0.35%	0.11%	0.10%
K	1.21	0.82	0.68	0.56	0.44	0.17

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*C_3H_6 is the assumed average composition of the unsaturated hydrocarbons.

44" REVERSING BLOOMING MILL ENGINE.

(Continued from page 166)

the gallery. A double feeder system is brought to the gallery from one of the power plants and usually these two feeders are used in parallel for supplying the induction motor of the flywheel M.G. set.

A small transformer 6600 to 440 volts with a 220 volt starting tap is used for supplying the power to the exciter set, blower and pump motors. As an emergency feature the Bethlehem Steel Company have brought the 440 volt ac mill circuit into the motor room sub-station. This circuit will be used for driving the exciter set, blower and fan motors, in case any trouble develops on the small transformer.

Ventilation of Motor Room Sub-Station.

As a convenient and effective means of keeping some of the mill dust and dirt out of the motor room substation, an additional duplicate blower equipment was installed in the basement and is arranged in conjunction with the other blower equipment, so that either blower equipment can be used to ventilate the room while the other is ventilating the reversing motor. This affords considerable means of protection in regard to keeping dust and dirt from settling in the motor room.

PRODUCTION TOPICS

THE ART OF MASONRY IN A STEEL PLANT.

By Robert Smith,

Master Mason Inland Steel Company.

The first thing is that the material used is very expensive and means a lot of lost money if it is not laid up correctly. It also means considerable loss in tonnage because as a rule there are no spare furnaces.

Not many years ago we paid little attention to the clay which we used to lay up the brick; instead, we always figured on the brick which gave us the best service. I have found that by using the proper kind of clay or cement that we are able to get at least 40 to 50 per cent more out of the same brick, which means much more tonnage for the plant. I don't care how good the brick are, or how perfect they are laid, if you don't have clay as good or better than the brick the work will not stand and there will be a large loss of brick, besides tonnage and labor.

Next in order is the proper kind of bricklayers to do the work. I have found that a poor bricklayer can do just as much harm to good material as bad clay will do with good brick. I have always made a study of my masons and have found that by placing them at work to which they are suited I am able to get much better work and more of it.

We are very particular with our bricklayers and material on blast furnace stoves and coke ovens on account of the enormous cost and loss of tonnage when a blast furnace or battery has to be shut down. It means a considerable loss of money too, so I feel that the best is not too good in laying up the blast furnace linings.

Soaking Pit Work.

We used to put the arches over the checker chambers with all 9 inch brick with a small rise, but this caused considerable trouble so that we gave the arches from 12 to 15 inch rise, and had 13x9x2½ silica end wedge brick made for the first two rings on the face of the arch, and from there on back we had 13x4½x2½ fire brick. These arches when put in right last from 12 to 18 months, while the old style lasting from one to three months only.

We have always tried to see that when the masons work on arches they use all the end wedges or the arches they can possibly put in, without over running the center. I mean by this that there are masons who will often use a No. 2 wedge or No. 2 arch and then, in order to keep from over running the center, they have to put four or five straight brick in. Using No. 1 means more wedges in the arch, thus enabling us to get at least 50 per cent better service out of this class of work and a great deal more tonnage. This also means a large saving in material and labor.

At one time I used 9 inch standard size brick in partition walls and side work, but I now use 18x9x4½ and 13x9x4½ blocks. The reason for using the two sizes is to properly bond the walls, and by using these kind of blocks we are able to do the work much faster and with fewer joints in the wall. When the mason lays one 18 inch block he has filled a space on the wall that would require seven 9 inch standard brick, which means that we are able to reduce labor considerably. We lay the brick with the clay mixed to a thick grout; by so doing we get a solid joint. At one time we put in the checker with 9 inch standard brick. We now use 10x4½x4½ and the reason for the change is that we had to remove the 9 inch brick to clean out the checkers, causing us to lose about 45 per cent of the brick on breakage. With the 10x4½x4½ we lose only about 15 per cent. Another advantage is that the 10 inch brick lay much more solid. Some seem to think enough heat cannot be gotten out of this kind of checker, but we find we have sufficient.

Today almost all of the steel plants are trying to get a checker from which the flue dust can be cleaned out without removing the checker. This will mean a large saving in labor, time and material. I know of several different kinds that are so arranged, but as they have been out but a short time I am unable to say which is the best. The checker I speak of mostly refers to open hearth furnaces. I have had considerable experience on open hearth furnace rebuilding, both gas and oil and have found it is much easier to build this kind of furnace for oil than it is for producer gas; also, it is not necessary to be as particular in building the furnace for oil.

We use very little silica cement, the brick being laid dry. This means that the work goes much faster and the cost of cement is eliminated. However, when using producer gas, everything has to be laid close and laid in cement, I mean on the port ends so as not to let the gas and air mix.

Open Hearth.

One of the first parts which have to be rebuilt on an open hearth oil furnace is the front and back walls, and every time these repairs have to be made it means a big loss in tonnage. I have found that if these walls are not banked correctly by the bottom maker after each heat, we are fortunate to get more than from 40 to 50 heats out before these walls have to be rebuilt. However, if they are kept banked up well with dolomite, we get all the way from 125 to 150 heats out of the same walls. To rebuild a front wall we must take off the doors and door frames, which means that the furnace is idle from four to five hours. Therefore all back and front walls in open hearth furnaces should be kept well banked.

Wherever we have arches that the skewback is supported off a wall, we lay a channel on top of same and bolt it to back buckstay. Then we set skewback on same. This is so that when we have to replace the walls below the skewback we can remove old walls and the channel will hold the skewback so that the arch will not fall. This scheme saves us lots of work and time. I have found that by setting the skewback brick for all furnace arches back 5 inches from the face of the jams we obtain better results and making the first courses a header so that if the jam is knocked out or was off 5 inches the arch will still have a good skewback, which means that the arch will not fall or that the jam can be repaired without losing the arch.

I feel that this has saved me a great deal of extra work and expense. I have always claimed that the correct way to lay firebrick is to boil the clay and mix it to a grout—just thick enough so that a solid joint will be made. I have found it is a hard job to make the bricklayers use old brick or bats. It seems in the majority of cases that if they want a half or a piece of brick, they will break a new brick; however, by continually keeping after them, this can be eliminated.

WITH THE EQUIPMENT MANUFACTURERS

The General Electric Company has recently developed a new turbine of the Curtis type suitable for driving such apparatus as blast furnace and converter blowers and centrifugal air compressors and exhausters for oil, gas, or powdered coal furnaces. The turbines are of one, two, or three stages, and operate at steam pressures of from 50 to 300 lbs., with or without superheat, and either condensing or non-condensing.

The turbine is constructed throughout so as to give the greatest strength and rigidity possible, and the casing is easily raised for inspection, or removal of the wheels. The steam connections are so arranged that they need not be disturbed when it is desirable to remove the top of the casing.

The turbine is equipped with speed control in the form of a centrifugal governor, and if desired an emergency governor. The first is of the centrifugal tension spring type, the motion of the weights being transmitted through ball bearing connections to the governor valve. The speed may be adjusted while the turbine is running by a simple operation of the governor valve. The emergency governor is attached, operates entirely independently of the main governor, when the speed rises to about 15 per cent above normal.

The steam passes through the first stage nozzles, from the steam chest, the nozzles being opened, or closed, as required by hand valves placed in the steam chest. The governors control the flow of steam to all nozzles.

JONES SPUR GEAR SPEED REDUCERS.

The Jones Spur Gear Speed Reducer is an enclosed spur gear drive with the high and slow speed shafts concentric and having the same direction of rotation, and is designed for reducing motor speeds by direct connecting the motor shaft to the high speed shaft of the reducer through a flexible coupling. The slow speed reducer shaft being coupled to the shaft of the driven unit causes it to rotate at any predetermined speed, depending on the ratio which has been selected to meet requirements.

Jones Reducers are adapted for driving practically all classes of mill, factory and plant equipment where a reduction in speed is necessary between the motor and the driven unit. They are particularly valuable where large speed reductions are to be installed in confined or restricted quarters, and where positive as well as economical operation is essential.

A few of the advantages obtained by the use of Jones Spur Gear Speed Reducers, as compared with other forms of transmission used to secure the same reductions in speed, are as follows:

1. Jones Spur Gear Speed Reducers occupy less space than other devices necessary to accomplish the same ratio of speed reduction.

2. Acid fumes, abrasive dust, or other adverse atmospheric conditions do not affect the successful operation of Jones Reducers.

3. Shafts and bearings are relieved of all cross strains and transverse loads.

4. Slide rails and adjustments for correct center distances are unnecessary where Jones Speed Reducers are used.

5. They require practically no attention; and are quiet, efficient and durable.

6. Jones Spur Gear Speed Reducers will decrease your installation costs.

7. All safety laws are complied with: There are no exposed moving parts that will cause injury to workmen.

Today, the works manager, superintendent, chief engineer, and master mechanic all realize that when installing new machinery, efficiency and safety are of prime importance, and that maintenance and working life must be considered as well as the first cost. The Jones Spur Gear Speed Reducer will bear the closest scrutiny along these lines.

The Jones Spur Gear Speed Reducer is designed to accomplish in the most direct and economical manner electric motor speed reductions in the various forms of industry. Its construction is simple, durable and compact, and once installed it requires no further attention, aside from an occasional supply of oil. It is fool proof, and dust proof, and it eliminates all the troubles common to belts, gears, chains or ropes, such as stretch, misalignment, lack of attention, excessive wear brought about by adverse atmospheric conditions; and on account of its totally enclosed feature affords complete protection against injury to careless workmen coming in contact with rapidly moving parts.

NEW HELICAL WORM GEARED CRANE LADLE.

The Whiting Corporation have recently put on the market a new style "Helical Worm" geared crane ladle. The distinguishing feature of this new ladle design is the fact that the gearing is mounted on the trunnion instead of on the bail. Consequently any distortion of the bail or bowl will not interfere with the alignment of the gears. A further advantage of this arrangement is that the gear alignment is not affected by wear on the trunnion journals.

This gear combination has the self-locking feature of worm gearing but by virtue of the balanced thrust obtained through the helical gears, and the efficiency of this gearing being much higher than that of the ordinary worm gearing, the power required to rotate is considerably less. The helical gear on the hand wheel shaft meshes with a helical gear on the worm shaft. The worm shaft is placed at an angle so that the worm will properly mesh with the large straight-toothed gear keyed to the trunnion. The large straight-toothed gear is of cast steel; the worm and helical gears are forged steel. All gears have machine cut teeth. The construction of the gear case is such that it will accommodate several different ratios of helical gears, depending on the speeds desired. This new style gearing is completely enclosed in dust-proof cover, yet readily accessible for inspection. Small oil cups with spring caps provide ample lubrication.

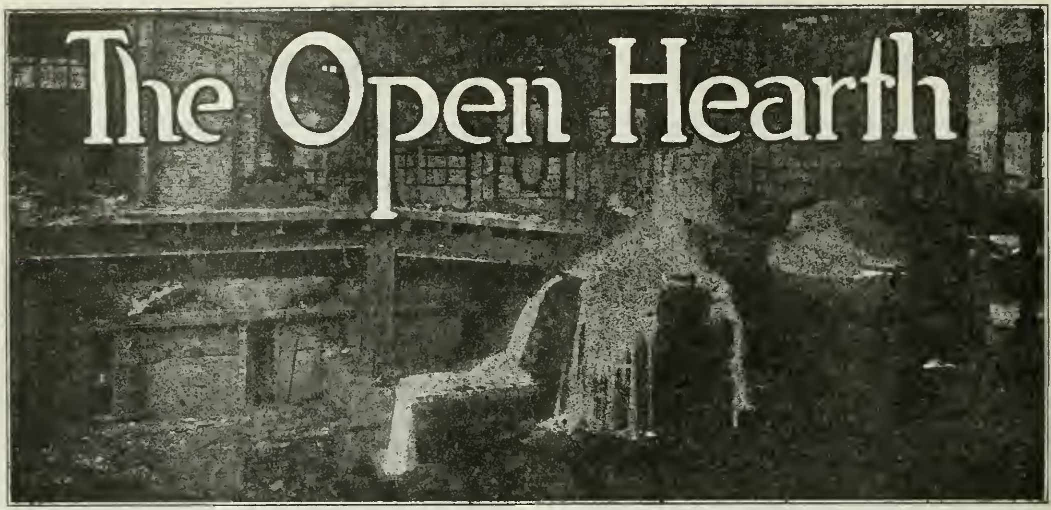
It is built under U. S. Letters Patent, Nos. 1,323,137 and 1,357,599 by Whiting Corporation, Harvey, Ill.

EFFICIENT COOLING COMPOUND FEED SYSTEM ADOPTED BY CLEVELAND MANUFACTURER.

In a recent visit to the Cleveland plant of the Steel Products Company, the writer witnessed a somewhat unique system for delivering oil or water to drill presses, lathes, tapping machines, centering machines, screw machines, etc., a large supply being constant to the latter whether the machines were running forward or in reverse.

The pumps used were a new type Ross "Two-Way" Centrifugal pump manufactured by the Ross Manufacturing Company also of Cleveland.

The Open Hearth



C. F. Banty has been appointed general foreman of stationary engines, South Side plant, Jones & Laughlin Steel Co.

V V

F. H. Moyer, formerly chief engineer of the Cambria Steel Company, Johnstown, Pa., has accepted the position as assistant to the plant manager with the Pittsburgh Crucible Steel Company at Midland, Pa.

V V

I. H. Billiar, works engineer of the Duquesne Steel Foundry Company, has been appointed assistant engineer of the Mayville, Wis., plant of the Steel & Tube Co. of America.

V V

A. V. Rigby, formerly assistant general superintendent of the Farrell works of the Carnegie Steel Company, has been elected president of the recently incorporated Rigby Valve & Machine Co., Sharon, Pa.

V V

Walter B. Clasper was presented with a gold watch and a fob recently by the management of the American Sheet & Tinplate Co., of McKeesport, Pa., when he joined the pension list. Mr. Clasper, who is 65 years old, has been in the employ of the company for 43 years.

V V

A. S. Taylor, formerly of the Bethlehem Steel Company, the Allegheny Steel Company, and for the past eight years, chief engineer of the United Alloy Steel Corporation, Canton, O., has gone to California to accept a position with the Moreland Truck Company at its new plant in Burbank.

V V

J. E. N. Carlson, formerly testing engineer for the National Tube Company at McKeesport, Pa., has been appointed steam engineer of the Gulf Refining Company at Port Arthur, Texas.

V V

Calvin W. Verity, formerly head of the betterment department of the American Rolling Mill Company, Middletown, O., has been elected treasurer of that company.

V V

Walter F. Ingals has been elected vice president of the Central Tube Company, Pittsburgh, Pa. Mr. Ingals has been general sales manager of the company since 1909, when it was organized, and he will continue as general sales manager.

Col. W. P. Barba, former vice president Midvale Steel & Ordnance Co., has been elected chairman of the board of directors of the Penn Seaboard Steel Corporation, Philadelphia, succeeding Rodney Thayer, who resigned. Mr. Thayer has returned to Europe where he will remain indefinitely. Alfred P. Sloan, Jr., vice president General Motors Corporation, has been elected a member of the company's board of directors. This makes two officials of the General Motors Corporation who are now serving as directors of Penn Seaboard Steel Corporation, the other being J. C. Weiss, president Hyatt Roller Bearing Company, Harrison, N. J., which is a subsidiary of General Motors.

V V

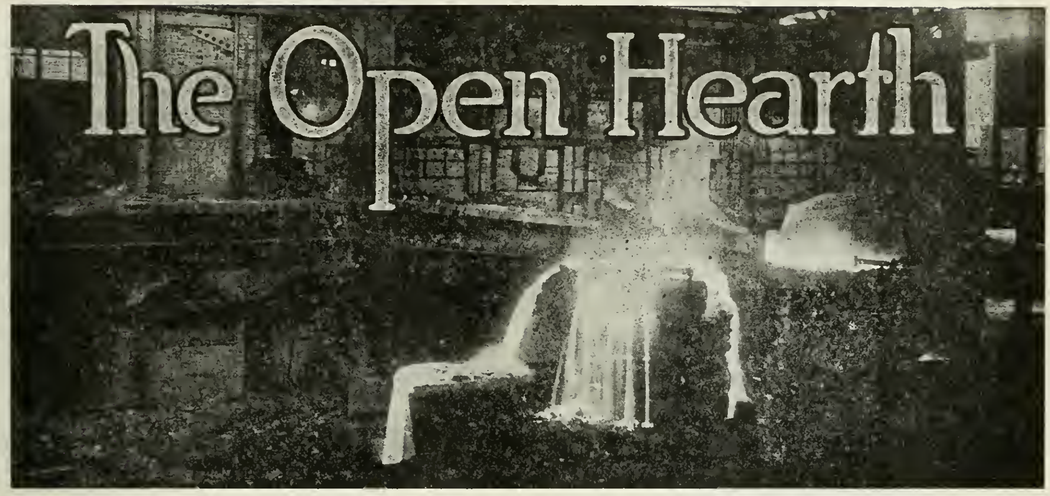
A. P. Preyer has been appointed Cincinnati district manager of the American Rolling Mill Company to succeed J. A. Henry, who resigned to enter business in Chicago. Mr. Preyer has been connected with the American company for over 15 years at the Middletown offices. He took over the Cincinnati office on January 1.

V V

D. E. Sawyer was again elected general sales manager for 1921 at a recent meeting of the board of directors of the Pollak Steel Company, and is still located at the New York office of the company. S. K. Morrow, formerly manager of operations, is now manager of sales for the three plants, with the offices at the Cincinnati works. C. G. Talbott, formerly assistant manager of operations, is now manager of rolled products for the Marion plant. A. C. Weihl, for several years superintendent of the Cincinnati plant, is now general works manager in charge of operations and productions of the Cincinnati, Chicago and Marion plants. V. W. Prather, formerly cost auditor for the Cincinnati plant, is now general cost auditor of three plants. R. A. Mitchell takes the position vacated by Mr. Weihl to become superintendent of the Cincinnati plant. J. H. Deickman becomes manager of materials and inspection of three plants. W. P. Woods becomes auditor and G. H. Tallaksen, superintendent of the Chicago plant.

V V

Max Maag of Zurich, Switzerland, inventor of the gears and machines that bear his name, sailed for home on December 4, after several weeks in this country, spent in looking after his gear interests here. He expects to return in the spring.



The Open Hearth

W. R. Webster has resigned his position as assistant chief engineer for the Cambria Steel Company, Johnstown, Pa., to become general engineer of the Semet-Solvay Company, Syracuse, N. Y.

V V

W. A. Maxwell, Jr., of Westmont, Pa., assistant general superintendent of the Cambria Steel Company, Johnstown, Pa., resigned, effective November 22, to accept the position as general superintendent of the Inland Steel Company plant at Indiana Harbor, Ind. H. A. Berg also of Westmont, superintendent of the blast furnace operations of the Midvale Steel & Ordnance Co., succeeds Mr. Maxwell.

V V

Frank Thornton, Jr., chief engineer of the Westinghouse Electric Products Company, has been appointed manager of the electric heating engineering department of the Westinghouse Electric & Mfg. Co.

V V

F. G. Allan, of Toronto, has been appointed general manager of the Pressed Steel Metals Company of Canada, Ltd., and American Bushings Corporation, in succession to J. W. Leighton, who is now chief engineer and supervisor of works. In addition Mr. Leighton will devote a portion of his time to the development of the patented bushings and tube processes.

V V

John H. Mowrey, of Philadelphia, Pa., has recently been chosen as the new general manager of the Worcester Pressed Steel Company of Worcester, Mass., and will assume his new duties January 1.

V V

William Philip Barba, who recently was elected chairman of the Penn Seaboard Steel Company, Philadelphia, Pa., formerly was prominently identified with the Midvale Steel Company, and the Midvale Steel & Ordnance Co. He was born in Philadelphia, March 6, 1865, and received his education in the schools of that city. He entered the employment of the Midvale Steel Company in 1880. He was appointed chief chemist in 1899. Five years later he was made head of the manufacturing department. In 1908, he was appointed general manager of sales, and in 1911, general superintendent. In 1915 he was made general manager and later in the same year, upon the acquisition of the property of Worth Bros. Company, Coatesville, Pa., by the Midvale Steel & Ordnance Co., he became vice president of the Worth Company. Later, he became vice president of the Midvalle Company, which office he held at the time of his retirement some time ago. He was also president and director of the Midvale Steel Company of Philadelphia and London, Ltd., and a director of the Midvale Steel & Ordnance Co.

V V

Willis F. McCook, president Pittsburgh Steel Company, was tendered a complimentary dinner and presented a gold loving cup by a number of his friends and associates at the University Club, Pittsburgh, on January 19, the anniversary of his birth.

V V

Dr. A. C. Lowry was elected president of the Marting Iron & Steel Co., at the annual meeting of stockholders at Ironton, O., on January 12. Other new officers are: Vice president, A. H. Mitendorf; secretary, Miss Margaret Rief; treasurer, C. E. Sullivan. The officers with C. A. Thompson, Dr. J. W. Lowry, W. P. Lewis, F. L. McCauley, F. L. Marting and C. B. Fowler, constitute the board of directors, C. A. Thompson being elected chairman.

V V

Dr. H. S. Murat has been appointed chief surgeon of the American Rolling Mill Company, Middletown, O., and will devote all his time to the interest of the employes and their families.

V V

George H. Danforth, recently elected president of the Engineers Society of Western Pennsylvania, is structural engineer of Jones & Laughlin Steel Co., Pittsburgh, and has been with that organization since 1900. He started as assistant structural engineer, assuming his present position four years ago. Mr. Danforth was born at Chelsea, Mass., 48 years ago, and for five years prior to becoming identified with the Jones & Laughlin Steel Co., was with the New Jersey Steel & Iron Co., Trenton, N. J., subsequently absorbed by the American Bridge Company, and the plant of which is now one of the fabricating shops of that company. He is a member of several Pittsburgh organizations and is a director of the Pittsburgh chapter of the American Welding Society.

V V

Louis A. Way, for the past four years works manager Lewis Foundry & Machine Co., Pittsburgh, has resigned and on February 1, becomes assistant to the president of the Duquesne Steel Foundry Company, Pittsburgh, in charge of sales. Before joining the Lewis Company, Mr. Way for about 16 years had been with the Duquesne Steel Foundry Company.

NEWS OF THE PLANTS

The Kansas City Bolt & Nut Co., Kansas City, Mo., is arranging for the installation of equipment at its new rolling mill, as originally planned, in the near future. Partially equipped, operations were inaugurated at the plant in December, and by the close of the present year it is expected to have the plant in full production. The installation will include a 22-inch finishing mill, four-stand, 12-inch continuous mill, 10-inch mill and 8-inch mill. The plant will specialize in the manufacture of merchant bars of small sizes and small structural shapes. It is proposed to develop an annual capacity of about 100,000 tons. In the open hearth department, two 50-ton furnaces have been installed and placed in service. These units will be augmented by three other furnaces, now partially constructed.

The Joliet Steel & Iron Company, Joliet, Ill., has awarded a contract to the B. & B. Construction Company, 6248 South Michigan avenue, Chicago, Ill., for the construction of an addition to its plant for increased capacity. The structure will be one-story, 75x160 feet, and is estimated to cost about $50,000, including certain alterations in present plant.

The Falcon Steel Company, Niles, O., has completed the installation of a new galvanizing department at its local sheet mill, comprising three main galvanizing pots. Preliminary plans are under way for extensive plant additions, doubling approximately the present output. The present works comprises six sheet mills and two large jobbing mills, and this installation will be practically duplicated. Up to the present time the company has specialized in the production of black and blue annealed sheets. It is planned to commence construction of the new plant units as soon as conditions in the trade warrant. Lloyd Booth, formerly connected in an official capacity with the Trumbull Steel Company, Warren, O., is president of the company.

The Apollo Steel Company, Apollo, Pa., has construction under way on a number of additions to its plant for extensive increased capacity. The structures include four new sheet mills, two jobbing mills, two new galvanizing pots, pickling department, warehouse and a number of miscellaneous structures. The new additions will develop a capacity of about 50,000 tons of finished material a year. It is expected to have the different units ready for service early in the spring. A number of electric-traveling cranes will also be installed.

The Fabricated Steel Products Corporation, 13 Park Row, New York, N. Y., is completing plans for the erection of an addition to its plant at Leetonia, O., for increased production. The new extension will be one-story, 90x115 feet, and with equipment is estimated to cost in excess of $50,000. The company specializes in the manufacture of tanks, pipe, troughs and kindred products. Harry Lindemann is president.

E. G. Tillotson, Cleveland, O., is at the head of a project to establish a new company for the operation of the Temple blast furnace of the Seaboard Steel & Manganese Corporation, located at Temple, Pa. The plant was recently secured by Mr. Tillotson and associates at a public sale for a consideration said to be about $75,000. The plant consists of two alternate stacks, one of 6,000 tons capacity per month, and the other rated at 4,000 tons. It is said that the new company will make a number of improvements in the plant.

The Bethlehem Steel Company, Lebanon, Pa., has construction under way on a battery of nine oil-burning drag furnaces, and two new over-fired heat-treating furnaces. A new cooper shop and galvanizing works are also in course of erection and are expected to be ready for service at an early date. Other buildings include a wire-drawing and pickling department. New electrical equipment will be installed at the power station at the works. At its Steelton plant the company is making a number of similar extensions, including nine oil-burning drag furnaces, installation of a number of new gas producers for the mill heating furnaces, new crane runway, motor-drive for 44-inch mill, and miscellaneous improvements for increased production in different departments of the plant.

The Pacific Coast Steel Company, Seattle, Wash., with works at Youngstown, near Seattle, has construction under way on a number of improvements at its mills for increased production. A new building, 88x420 feet, is now nearing completion, to replace a former 16-inch roughing mill and 12-inch finishing mill. The equipment in the new building will be arranged to operate in tandem, electrically driven. The two finishing sets of the 12-inch mill will be equipped with automatic hotbeds, as well as with dividing shear, located between the roughing mills and finishing mills. A new 14-inch roughing mill with 10-inch finishing mill will be installed at the plant, to be equipped with two stands of 8-inch rolls, driven independently. This latter equipment will be used for the production of small bars and shapes. A new universal train for rolling plates up to 20 inches wide will be installed in connection with a present 22-inch mill. It is expected to complete the majority of this work early in the present year, and place the equipment in service immediately thereafter. At its open-hearth steel plant the company has four 40-ton furnaces, utilizing scrap and pig iron. The different products include open-hearth billets, channels and other structural shapes, sheet bars, merchant bars and other specialties, particularly of small size. A branch works is operated at San Francisco, Cal., consisting of an open-hearth steel plant and finishing mills. The open-hearth department has four 40-ton and two 25-ton furnaces, as well as finishing mills of different size. The open-hearth units are using scrap and pig iron. This plant has a capacity of about 10,000 tons of material a month, or the same as the Youngstown works. E. M. Wilson is president of the company; executive offices are located in the Alaska Building, Seattle.

The Trumball-Cliffs Furnace Company, Warren, O., is considering plans for the construction of a new blast furnace of about 600 tons capacity. It is expected to have the new unit ready for service at an early date, with entire output utilized at the works of the Trumbull Steel Company, with which the organization is affiliated. A new ore-handling bridge and car dumper will be constructed in connection with the new furnace. The Cleveland Cliffs Iron Company, Cleveland, O., is also interested in the company.

The Sharon Steel Hoop Company, Sharon, Pa., has plans under way for the construction of an addition to its plant for increased capacity. The proposed structure will be of brick and steel, and is estimated to cost about $150,000. The J. H. Herron Company, 1350 West Third street, Cleveland, O., is architect and engineer.

Some Pointers on By-Product Coke Oven Operations

ACCIDENTS IN BY-PRODUCT COKE OVENS.

(Continued from page 151)

the use of ordinary care in the operation of this department. While it is true that the industrial railroad is much more dangerous than the public carrier, due to cramped yard conditions and usually poor track clearance, yet the hazards are the same and can be guarded against just as well.

The one great thing needed to make safety show results in the coke oven industry is the furthering of foreman education. Foremen are lax about taking the responsibility of educating the men placed under their care in the rudiments of prime safety. There is as much difference between telling a man to be careful while doing a job and telling him the safe way to do it, as there is between day and night. Foremen are hired to direct the work properly and not to leave it to the workman's own way of doing it. After a plant is pretty thoroughly guarded foremen should be held to strict accountability for all accidents occuring to their men. They should be called on the carpet on account of a serious accident to one of their men just as quickly as they would in case of some defect in their work or production. Foremen that have many accidents have not got their men working with them, not only in accident prevention, but in all lines of work. You can't be an efficient foreman and have accidents in your department, because accidents and efficiency do not mix well.

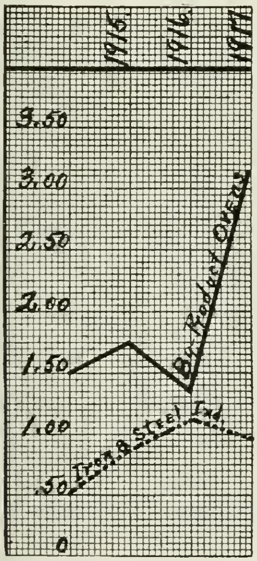


Fig. 3—Comparison of the fatality rates of the by-product ovens and the iron and steel industry for the years 1915-17. Number killed per 1,000-300 day workers.

Enough data has been given to show where the greatest effort must be put forth in order to reduce the accident rate of the industry, and it is up to you to look your organization over and see where your accidents originate. Are you behind your safety department as you should be? Makes no difference how small your plant, you should have some kind of a safety department in order to keep your accidents at the lowest possible minimum.

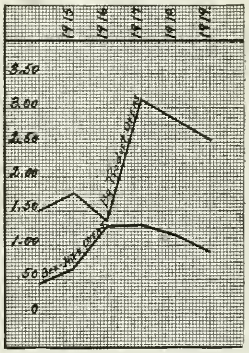


Fig. 4—Comparison of the fatality rates of the beehive coke ovens and by-product ovens for the years 1915-19. Number of fatalities per 1,000-300 day workers.

Acknowledgement is hereby made for the free use of Government Bulletins in the preparation of this manuscript, especially the one by W. W. Adams, on "Coke Oven Accidents for the Year Ending December 31, 1919." All assistance possible should be given to the Department of the Interior in the preparation of these bulletins. realizing that you are rendering a service to mankind in general when you do it. The alleviation of the suffering and misery due to accidents should be one of your guiding principles in the conduct of your business.

The Atlas Crucible Steel Company, Dunkirk, N. Y., has construction under way on a new wire mill at the plant, forming an extension to the present department at the plant. The company has arranged for the operation of additional equipment during the coming year, to include a new 16-inch and 26-inch rolling mill, to be used exclusively for alloy steel manufacture. It is proposed to develop an additional capacity of about 20,000 tons with the new units.

V V

In an article entitled "Steel Plant Power Generation From Waste Heat and Coal," which appeared in the December, 1920, issue of BLAST FURNACE AND STEEL PLANT, the author's name did not appear along with the footnote which should have read, "abstract of paper delivered before the Association of Iron and Steel Electrical Engineers Society by B. H. Greene, Steam Engineer, United Alloy Steel Corporation, Canton, O.

TRADE NOTES

H. J. Moyer, who has jointly represented Yarnall-Waring Company and Nelson Valve Company, for the past several years in the Chicago territory, has now severed his connection with the latter concern, and will henceforth represent the Yarnall-Waring Company exclusively in that field, as district manager. Mr. Moyer's office is now located at No. 58 West Washington street, Chicago, Ill.

The Wellman-Seaver-Morgan Co.'s Atlanta district office has been transferred to Birmingham, Alabama, Room 302, American Trust Building. Mr. Quinn W. Stuart continues as district manager.

A. E. Hogrebe, mechanical and electrical engineer, of Baltimore, Md., has been appointed sales engineer of The Champion Engineering Company, of Kenton, Ohio, manufacturers of Champion electric traveling cranes, in charge of crane sales for the newly created Baltimore territory so R. W. Walls, vice president and general manager of The Champion Engineering Company announces. Mr. Hogrebe has been identified with the design and later with the manufacture and sales of electric traveling cranes since 1891, having been connected since that time with the following crane builders: Yale & Town Mfg. Co., Stamford Conn.; Brown Hoisting Machinery Company, Cleveland, Ohio; Pawling & Harnischfeger, Milwaukee, Wis. He was also chief engineer from 1899 to 1917 of the Niles, Bement, Pond Company, Philadelphia, builders of Niles cranes.

The Locomotive Superheater Company, with general offices 30 Church street, New York City, announces that on January 1, 1921, they will open their own company office at 382-388 Union Arcade building, Pittsburgh, Pa. John R. LeVally, formerly sales engineer with the Chicago office of the Locomotive Superheater Company, has been appointed district manager.

The U. G. I. Contracting Company, of Philadelphia, has appointed A. E. Blake to be its representative in the Pittsburgh district, beginning January 1, 1921, with offices in Union Arcade. Mr. Blake has represented the Surface Combustion Company, of New York, in the Pittsburgh district for the past three years.

The Whiting Foundry Equipment Company, Harvey, Ill., announces that it has changed its name to Whiting Corporation, increasing its authorized capital stock from $700,000 to $3,000,000. The Whiting Corporation remains under the same management and will continue the manufacture of cranes, foundry equipment and railway specialties as heretofore.

In the January issue of The Blast Furnace and Steel Plant it was stated that Smith Gas Producers had been ordered by the Electric Storage Battery Company. Statement was made that the producers installed were the Smith Type "G" for using bituminous coal. The producers installed were not the Type "G" but the Smith Type "E" Producer, for use with anthracite coal.

The Wellman-Seaver-Morgan Company report the receipt of an order from the Western Maryland Railway Company for an improved boat loading plant for cargoing and bunkering all sizes of vessels from bay schooners and tugs to 20,000 ton ships. The equipment is to be installed at Port Covington, Baltimore.

The Northern Engineering Works crane and hoist builders of Detroit, have established a new office in the Pittsburgh district. The office is located at 990 Union Arcade Building, and will be in charge of J. B. Laird, who has hitherto represented the company in western New York and northern Pennsylvania.

The Mesta Machine Company, of Pittsburgh, Pa., announces the opening of a branch office at Chicago, Ill. The offices are temporarily located in the Railway Exchange Building, but will be moved to permanent quarters in the McCormick Building after April 1. The Chicago office will be in charge of Mr. C. J. Mesta, second vice president of the company. Messers. W. R. Dawson and R. W. Schutte will be transferred from the Pittsburgh offices to Chicago.

The Mesta Machine Company has recently opened offices in the Singer Building, New York City. The offices are in charge of M. M. Moore who was formerly export sales manager, located at Pittsburgh. Frank A. Mesta will also be transferred from the Pittsburgh office to the New York office as assistant to Mr. Moore. The company will retain its offices in the Munsey Building, Washington, D. C.

After endeavoring for some time to locate suitable office space in St. Louis, The Cutler-Hammer Mfg Company, of Milwaukee, has finally secured offices in the Railway Exchange Building, Suite No. 2111. This office is a branch of the Chicago district office, and its need has been evident for some time because of the increasing amount of business done in the St. Louis territory. Mr. Harold Phillips, formerly of the engineering department, of Chicago, and later office manager of the Chicago office, will be in charge of the new St. Louis branch.

TRADE PUBLICATIONS

The Aldrich Pump Company, of Allentown, Pa., manufacturers of triplex and quin triplex power pumps and hydraulic machinery, have recently issued Pump Data No. 47 illustrating a part of a large group of pumps which they term, "modified pot chamber water end type", because of the fact that the working barrel and valve chambers of each plunger are contained in single and interchangeable castings or forgings.

The Milwaukee Electric Crane & Manufacturing Company, of Milwaukee, Wis., has just issued a new 48-page catalog illustrative and descriptive of the complete line of cranes made by this company. Much valuable information, the result of 25 years of active experience in the designing and building of hoisting machinery for shops, foundries, steel plants, and other establishments is incorporated in this book.

The Electric Furnace Construction Company, Philadelphia, announces the starting up of a "Greaves-Etchells" Electric Furnace at the Holmes Foundry Company's plant, Port Huron, Mich., for refining and superheating molten cupola metal.

"Chronology of Iron and Steel" is the title of a recent book distributed by the Pittsburgh Iron and Steel Foundries Company. The data was compiled by Stephen L. Goodale, Professor of Metallurgy in the University of Pittsburgh, and was edited by J. Ramsey Speer, Chairman of the Board, Pittsburgh Iron and Steel Foundries Company. The following editor's note best explains the nature of the text "we have given facts as we have found them," referring to the American, the English, the French, the Swedish and German peoples and many others.

Ross Heater & Mafg. Co., of Buffalo, N. Y., have issued Catalog F, which covers the Ross Heater of the closed or tubular type, the general features of which are well known to those familiar with this class of machinery.

The Cutler-Hammer Mfg. Co., of Milwaukee, Wis., are distributing a new publication, 875, which will be of interest to men of the gas industry. It is a 12-page, 8½ x 11 booklet descriptive of the Thomas Meter, which is used for measuring large quantities of commercial gases and air. The operation of the meter is briefly given so as to be readily understood and its various uses are presented. This meter measures the gas directly in standard cubic feet with no corrections necessary for pressure, temperature and atmospheric conditions, and the panel on which the totalizing and recording instruments are mounted may be located at any convenient place where the readings are desired, which may be quite a distance from the meter housing. The various parts of the meter are illustrated and described and several views show installations in blast furnace plants, steel mills, city gas plants and distributing gas companies.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., MARCH, 1921 No. 3.

Electric Furnaces for Making Steel

Classification of Electric Steel Making Furnaces—General Features and Advantages of the Arc Furnace and the Resistance Furnace—Operating Features of Electric Furnaces.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART I.

THE electric steel furnace is a furnace heated electrically and employed for the production of steel. This type of furnace is intended as a rule for making steel from a metallic charge and not from iron ore, although it may occasionally be used for ore-smelting. The electric furnace may be used for melting steel scrap or mixtures of steel scrap and pig iron, or on the other hand it may receive molten steel that has been made in a Bessemer converter or open-hearth furnace. It may function merely as a melting furnace or it may be used for refining or purifying the material supplied.

Most electric furnaces used for steel-making are heated by means of electric arcs; these arcs being the chief means whereby the electric energy supplied to the furnace is converted into heat. In some furnaces, on the other hand, no arc is formed, and the heat is produced by the passage of the electric current through the molten steel that is being treated. Electric furnaces vary greatly in shape, size and construction, but they can be classified most satisfactory with regard to the means whereby the electrical energy is converted into heat.

Classification.

Electric steel furnaces may be divided in the first place into arc furnaces, which are heated mainly by means of one or more electric arcs, and resistance furnaces, in which no arc is employed and in which the heat is produced by passing an electric current through some solid or molten material.

Arc furnaces may be divided into "independent arc furnaces," such as the Stassano and Rennerfelt furnaces, in which the arc is struck between two or more carbon or graphite electrodes and is independent of the material of the charge, and "direct-heating arc furnaces," such as the Heroult and Girod furnaces, in which each arc is formed between one carbon electrode and the metal of the charge or its covering slag.

The independent arc furnace has the advantage that it can be operated when it is empty, which may be needed for making or repairing the furnace lining, and that a fairly steady electrical load can be maintained even when melting cold scrap. On the other hand, as the heating arc is produced between electrodes and is not in contact with the metal, the trans-

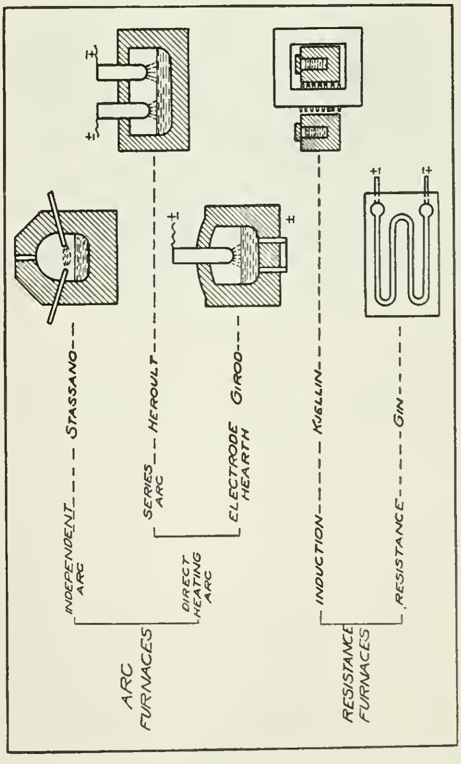


Fig. 1—Classification of electric steel-making furnaces with typical examples.

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*These articles form part of a book on the Electric Metallurgy of Iron and Steel to be published by the McGraw-Hill Book Company.

fer of heat to the charge is less perfect than in other types and the efficiency is consequently less; although in the Rennerfelt furnace the arc is blown magnetically against the metal to be melted, thus raising the efficiency.

In direct-heating furnaces each arc is formed between an electrode and the metallic charge in the furnace, which thus forms one pole of each electric arc. The heat is produced partly on the surface of the charge, where the arc strikes it, partly in the arc itself and partly at the tip of the electrode. When, as is usually the case, short low-voltage arcs are employed, the heat from the upper electrode, and from the arc, is largely radiated downwards and is absorbed by the metal of the charge; being held down by the electrode itself, if this is of sufficient cross-section, and prevented from escaping towards the roof of the furnace. These furnaces should consequently have a high efficiency, but they have the disadvantage that they cannot be operated when empty, some conducting material such as coke being needed to carry the current when the furnace is heated without a charge for baking a lining; moreover the electrical load is apt to be very irregular when melting a cold charge of metal.

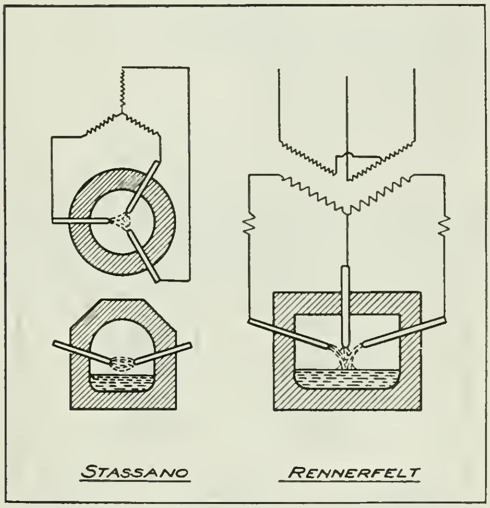

Fig. 2—Independent arc furnaces.

A further comparison may be made between these types of furnaces in respect to the temperature of the molten slag or metal. The direct-heating arc produces an extremely local temperature beneath each arc. This effect is desirable in steel-making because it enables sulphur to be eliminated more completely, while for certain other operations, such as brass-melting, the high local temperature would be very objectionable, as it would lead to excessive volatilization of the metals forming the alloy. In the Rennerfelt furnace, although the arc is not direct-heating, an electro-magnetic flame is directed against the molten contents of the furnace and a fairly high slag-temperature can thus be obtained.

Some writers limit the term arc furnace to the class of "independent arc furnaces" in which the arc is formed between carbon electrodes, and employ the term resistance arc furnace for the class of "direct-heating arc furnaces," because in them the electric current passes through the molten metal and slag, as well as through the arc, and there is therefor a certain amount of resistance heating. The molten metal between the arcs in a Heroult furnace has a very small electrical resistance, and in consequence the heat produced in it by the passage of the current must be very small in comparison with the heat produced in the arcs, although an appreciable amount of heat will, no doubt, be produced by the passage of the electric current through the layer of slag. It appears to the writer that the fact of the arc being formed directly on the metal to be heated, which is indicated by the term "direct-heating," has a far more important effect on the operation of the furnace than the resistance effect of the metal in the charge.

Direct-heating arc furnaces may themselves be divided into series-arc furnaces—such as the Heroult furnace, Fig. 1, in which two arcs are operated in series and in which no electrical contact need be made to the hearth of the furnace, and electrode-hearth furnaces such as the Girod furnace, Fig. 1, in which the hearth of the furnace constitutes one electrode, and the arcs, if there are more than one, are not operated in series.

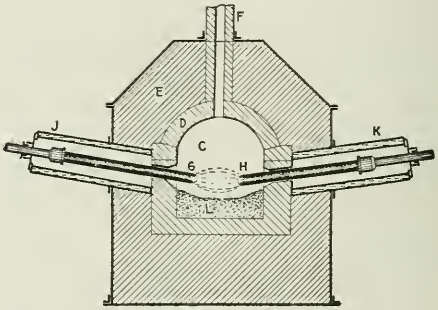

Fig 3—Stassano furnace—stationary.

Series-arc furnaces, of which the Heroult is the best known example, have the following principal advantages:

1. As two arcs are connected electrically in series the furnace can be operated at a high voltage without the use of long arcs. Electrical power can be supplied to furnaces more cheaply and efficiently at a high voltage than at a low voltage, and short arcs in general more efficient than long arcs because the heat is produced in closer contact with the metal to be heated.
2. The absence of any electrical contact through the furnace bottom makes the latter easier to repair and less likely to be destroyed by over-heating.

Electrode-hearth furnaces were originally represented by the Girod furnace, Fig. 1, and the Keller furnace, but in recent years a large number of furnaces of this type have been developed, including the electro-metals, the Snyder, and the Greaves-Etchells. Some of these, such as the smaller forms of the Girod, Keller and Snyder furnaces, are especially simple in construction, having only one movable electrode, and being heated by a single arc; in larger forms of the Girod furnace, two or more arcs are produced and an equal number of movable electrodes are needed, but the electrodes are all connected together and the arcs are operated in parallel. The more recent furnaces of the electro metals, Greaves-Etchells and Snyder variety use two-phase or three-phase current with a common return to the base of the furnace.

Electrode-hearth furnaces offer the following general advantages compared with series-arc furnaces:

1. In the series-arc furnace, using single-phase current, if one arc should break, the other arc is necessarily interrupted, and contact with the charge must be re-established with both movable electrodes, or with two electrodes in a three-phase furnace, before either arc can be started. In the electrode-hearth furnace, the arcs, if there are more than one, are independent of each other, and each arc can be started again by moving a single electrode.

2. As the electric current flows through the furnace hearth it will produce heat in the hearth itself and in the lower portion of the metal bath, while in some cases an electrical circulation is produced which stir up the molten metal and keeps it mixed.

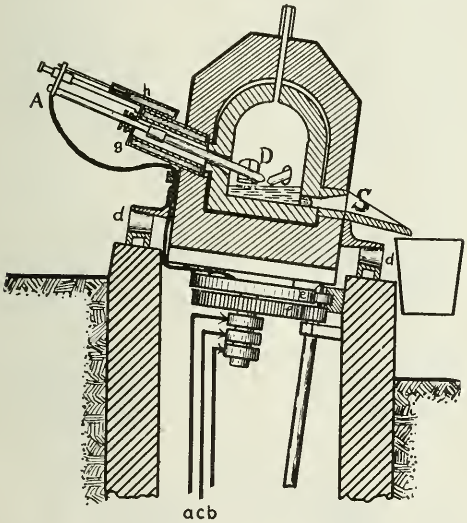

Fig. 4—Stassano furnace—revolving.

3. Although in general the electrode-hearth furnace has a lower voltage, because only one arc is operated in series, yet in one variety, the Snyder furnace, a high voltage is employed with the aid of an electrical steadying device. The high voltage enables a very long electric arc to be maintained, and this renders easier the melting of cold scrap, as the long arc is less easily broken than a short one, and produces a more uniform heat throughout the furnace.

Resistance furnaces are usually operated without electrodes, the electric current being generated inductively in the metal of the charge. Such furnaces, of which the Kjellin and the Northrup are examples, may be termed induction transformer furnaces. A few furnaces, such as the earlier form of the Gin furnace, Fig. 1, and the Hering furnace, employ electrodes and separate transformers, and these are termed resistance furnaces.

The electrical resistance of a mass of molten steel is so small that an enormous current at a very low voltage must be used for heating it, and as such a current cannot be led into a furnace by means of electrodes, without very heavy losses, it is usual to operate resistance furnaces on the induction of transformer principle which enables electrodes to be dispensed with.

In some resistance furnaces, chiefly of small size, such as the Helberger furnace, the resisting element is not the steel itself but a crucible, consisting in part of graphite, which contains the steel and is itself heated by the passage of the current. This type of electric furnace can scarcely be used for steel melting except on a small scale.

The classification of electric steel-furnaces can be understood very readily by reference to Fig 1.

Independent-Arc Furnaces.

In this class of furnace the arc is maintained between the ends of two or more movable electrodes which are made of carbon or graphite. This construction renders the arc independent of the material forming the charge, and the furnace can be heated equally as well when it is empty as when it contains a charge of metal. On the other hand, as the contents of the furnace are heated by radiation from the arc, this type of furnace is likely to be less efficient than the direct-heating arc furnace in which the metal to be heated forms one pole of each arc. There are two important examples of this class: the Stassano, which is heated by a three-phase arc between the ends of three nearly horizontal electrodes, and the Rennerfelt, which employs a two-phase arc between three electrodes. The Rennerfelt furnace has the advantage that the arc is forced downwards, like a blow-pipe flame, and so heats the contents of the furnace more rapidly. This feature is not claimed for the Stassano furnace but if the electrodes are inclined to the horizontal there will tend to be a downward motion of the arc. The electrical arrangement of these furnaces is shown diagramatically in Fig 2.

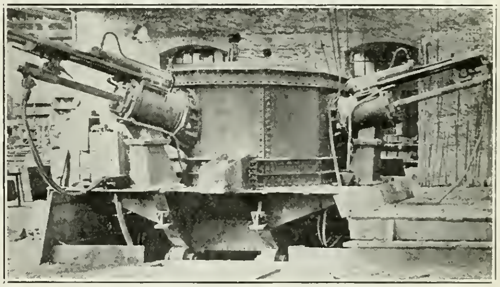

Fig 5—Stassano furnace—tilting.

Stassano Furnace.

This furnace was devised by Captain Stassano for the purpose of smelting iron ore. After a number of experimental designs, he arrived, about the year 1902, at the form shown in Fig. 3. This consists essentially of a refractory chamber, of about one meter internal diameter, lined with magnesite bricks, and provided with two lateral electrodes for simple-phase current. The electrode holders are contained within water-cooled chambers, which enable the furnace to be almost air-tight, and the electrodes can be adjusted by means of hydraulic cylinders. The furnace was sometimes stationary, as in Fig. 3, but usually it was made to rotate, see Fig. 4, and as it was mounted at an angle to the vertical the rotation had the effect of stirring up the contents of the furnace. The materials of the charge are introduced through the door D and the molten steel is allowed to flow out by the tapping hole and spout S. When employed for ore-smelting the crushed ore was mixed with charcoal and flux and was briquetted before being charged into the furnace. The heat of the furnace caused the ore to react with the charcoal, thus producing metallic iron. This was melted and finally tapped out as steel of any desired composition. The furnace operated satisfactorily and produced steel of excellent quality, but the cost was too high and the smelting of iron ore in this type of furnace was abandoned. The furnace has remained in use in Italy and elsewhere for making steel from a metallic charge.

The rotation of the furnace rendered more difficult the supply of electric power and cooling water, and, with a view to simplicity and cheapness of construction, a more recent form of the furnace is arranged to tilt instead of revolving. A photograph of this form is shown in Fig. 5, which represents a furnace in use in Germany before the war. Another form which was installed in California[6] is mounted like a ship's compass, and by means of gearing it is made to oscillate slowly to stir the charge, as shown in Fig. 6.

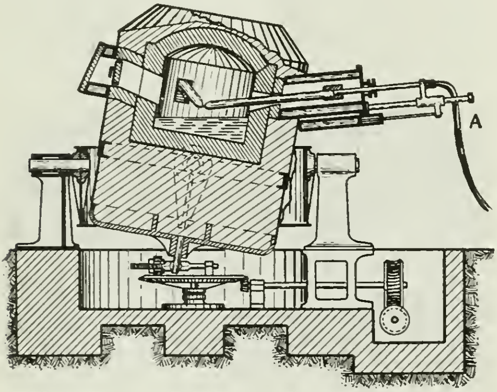

Fig. 6—Stassano furnace—oscillating.

The Stassano furnace uses single phase or three-phase current at a voltage of from 75 to 150 volts, according to size. The current varies from about 1,000 to 3,000 amperes per electrode, the power-factor is high, usually 90 or 95 per cent, and the electrical load is very steady, seldom varying more than 10 per cent above or below the average. The electrodes are of amorphous carbon and vary from about 3 inches to 6 inches in diameter; they are made in lengths of 5 feet and are used until only about 6 inches remains, when the furnace is stopped for a few minutes and a new electrode is introduced. The consumption of electrodes is about 20 pounds per ton of steel, costing about 80 cents. One man is needed to regulate the electrodes of each furnace as automatic regulators are not employed. The electrodes, in a vertical furnace, having an inclination of about 1 in 6, which serves to bring the arc nearer to the melted steel without danger of the slag getting into the electrode openings. The inclination of the electrodes has also an electro-magnetic effect tending to depress the arc (see discussion under Rennerfelt furnace) which would otherwise tend to rise in the furnace on account of its high temperature. The arc in the Stassano furnace is actually bent slightly downward, and when the charge is high in the furnace, the arc passed down from each electrode to the slag and metal as in a Heroult furnace. Owing to the construction of the furnace this condition cannot be brought about at will as in the recent forms of the Rennerfelt furnace.

The high voltage (150 volts for a 1,000 hp furnace) at which Stassano's furnace operates, gives a high electrical efficiency, because the electrical losses in transformers, cables and electrodes are less than in a furnace using a lower voltage. The electrodes themselves are operated at a high current-density, 100 amperes per square inch in the large furnaces, and this entails a considerable heating effect and consequent drop of voltage in the electrode itself. As however the electrode is mostly contained within the furnace this heat is not entirely lost but is communicated in part to the metal of the charge, and the high electrical resistance of the electrodes has the desirable effect of making the arc more stable.*

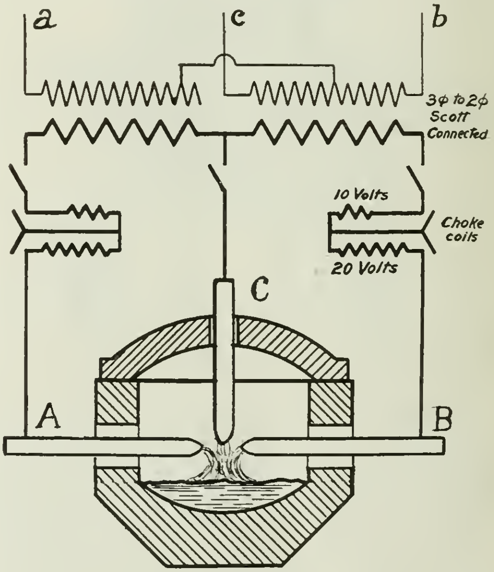

Fig. 7.

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*A six-inch electrode 5 feet long, carrying 2,700 amperes, has a current-density of 100 amperes per square inch and an electrical resistance of 0.003 ohm. It would cause a drop of 8 volts and a heat-production of 23 kw. The heat produced in the three electrodes would amount to 70 kw. or 10 per cent of the power supply. The diameter of a 5-foot electrode, carrying 2,700 amperes and heated at one end to 3,700 degrees C., should be 8½ inches according to Hering's formula or twice the cross-section actually employed. As, however, the electrode is mostly contained within the furnace this heat is not entirely lost but is communicated in part to the metal in charge, and the high electrical resistance of the electrodes has the desirable effect of making the arc more stable.

The Stassano furnace, having an independent arc, can be operated easily, and with a steady load, whether it is empty or contains a charge, and even when melting cold scrap. The heat of the arc, however, spreads generally throughout the furnace, instead of being given directly to the charge as in the direct-heating arc furnaces, and in consequence the thermal efficiency is not very high and the roof of the furnace needs frequent renewal. The thermal efficiency is improved by the thick walls and roof of this furnace, but this feature shortens the life of the roof, which is said to last only one week[12] and the cost of refractories, before the war, was over $2.00 per ton of steel.

Furnaces have been made of three sizes, small single-phase furnace of 100 hp and three-phase furnaces of 200 hp and 1,000 hp. The 200 hp furnaces hold about 650 kg of steel (two-thirds of a ton), while the 1,000 hp furnace held 4,000 kg, or four tons of steel. The cost of a 1,000 hp furnace is given by Stassano[1] as $5,000, while Osann[9] quotes a cost of $8,750 for a one-ton furnace (250 hp), including foundation and switchboard.

The performance of the Stassano furnace as a steel melter may be gathered from the following data:

1. In a small furnace of 600 kg capacity and 200 hp which was operated at Turin in 1905 for the production of steel shells for the Italian Government[8] each charge contained 150 kg of cast iron, 29 kg iron ore, 6 kg lime and about 450 kg of steel scrap. Each charge required about 850 kw hours, including transformer losses, or about 1,400 kw hours per ton of steel. Two thousand five hundred kg of steel was made daily so that each heat required about six hours and the power supplied was about 150 kw. The melting loss was not over 2 per cent even when 75 per cent of the charge was turnings. Stassano estimates the efficiency of the furnace at 15 per cent, which can hardly be accurate because steel scrap is regularly melted in modern furnaces with twice the efficiency that was obtained in this small furnace.

2. In a later report of the 200 hp furnace at the Royal Artillery Works[5], the furnace was employed to melt and refine steel scrap, and the consumption of power amounted to 1,250 kw hours per metric ton of steel.

3. A 200 hp furnace at Stassano's plant in Turin, mentioned in the same report, was making low-carbon steel from a charge of steel scrap and pig-iron, with a consumption of 1,260 kw hours per ton.

4. A furnace of 1,000 hp, at the same plant, made shell-steel from charges of steel scrap and pig-iron with a consumption of 920-960 kw hours per metric ton.

5. The oscillating furnace installed in 1913 at Redonto, California, had a capacity of 2,000 pounds and a power of about 200 hp. A charge, consisting mostly of steel scrap, required about five hours to melt and finish with a consumption of about 1,000 kw hours per net ton.

The furnaces at the works of the Stassano Electric Furnace Company at Turin, about the year 1908, were as follows:

Two 100 hp single-phase taking 1,000 amps., at 75 volts.
Two 200 hp three-phase taking 900 amps., at 100 volts.
Two 1,000 hp three-phase taking 2,700 amps., at 150 volts.

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2. Electrochem Industry, 1903, Vol. I, pp 247, 363, 461. Goldschmidt.
3. Electrochem Industry, 1905, Vol. III, pp 391. Stassano patent.
4. Electrochem Industry, 1908, Vol. VI, pp 315. Stassano.
5. Electrochem Industry, 1911, Vol. IX, pp 641. Catani.
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11. Journal Iron & Steel Inst., 1911, Vol. II, pp 215. Catani.
12. American Electrochem Society, 1916, Vol. XXIX, pp 507. Vom Baur.

(Continued in April issue)

Gases Obtained in Molten Steel

Dealing With the Gases Which Manifest Themselves During Steel Making Operations—Classification of the Gases and How to Deal With Them in Order to Make the Product Sound.

By HENRY D. HIBBARD.

PART III.

THE genesis of skin holes when present in would-be effervescing steel is probably as follows: Let us consider first the extreme case where these holes infect the whole ingot surface as thickly as possible. In the melting furnace such steel boils too mildly because of too high a temperature or not enough oxygen (ore), one or both, and as a consequence it contains more hydrogen gas than it should; as with a more vigorous boil the escaping CO bubbles would have carried more of it off. In the mold therefore the point of saturation of hydrogen in the metal is quickly passed as the steel cools and the gas begins to separate, forming at first small bubbles which adhere to the solidifying walls. In the extreme case we are considering there is no escape of gas in the mold which would, if plentiful enough, have an important effect in preventing skinholes. The hydrogen bubbles grow by accretions of gas from the cooling steel while the metal between them gradually freezes, forming the thin separately partitions. The bubbles grow naturally in the direction of the least resistance, which is toward the center of the ingot. Hence their elongated shapes and axes normal to the cooling surface. They continue to grow as fast as the ingot wall solidifies until at some certain depth they all cease growing. The reason why they thus cease does not appear, but that is of no practical moment to the steel maker, as the steel is irretrievably bad. If the boil in the furnace has been more active, so as to be but partially inadequate, the hydrogen content of the metal will be less than in the extreme case described and the saturation point will not be reached in cooling until a skin of solid steel of some thickness has been formed say from ¼ to 1.2-inch thick. A zone of smaller and more nearly spherical bubbles will then be formed which may not be particularly harmful if their outer skin be not burned through in the heating furnace. There will be some effervescence due to the escape of CO in the mold, but the steel will rise to the extent of the collective volume of the diminished skin holes. In other cases of insufficient effervescence, relatively few and small skin holes will occur, and often in clusters or groups which nevertheless are enough to condemn the part of a plate containing them to the scrap heap. When the boil in the furnace is active enough the hydrogen content is cut down on an allowable amount. The effervescence in the mold is brisk. Hydrogen bubbles do not begin to separate until perhaps ¾-inch of solid steel has formed and then such as do form are dislodged and swept away by the rising bubbles and the currents of metal they cause. A few around the bottom where the evolution of gas is less copious may escape such action and remain but they will not do much harm.

The second variety under Class III are the intermediate holes (sometimes called deep-seated holes), and they occur in effervescing low carbon steel in a zone between the surface and the center of the ingot from one to three inches from the surface, depending on the size of the ingot and the efficiency of the effervescence. They are more nearly spherical in shape than any of the other gas holes. As already stated, these holes are thought to be made by carbonic oxide. Some of the last of that gas to be expelled from the mushy central metal is mechanically held in bubbles against the already frozen wall, while the remainder is still able to rise to the surface and escape. Where there is no effervescence, as in the case of excessively high casting, temperature and as a consequence a profusion of skin holes there are no intermediate holes. As already stated in this case the CO in the liquid steel seems to be decomposed by the added manganese because of the unduly high temperature.

The third variety under Class III are the gases which form the central holes which are scattered at random in the central part of the ingot, the part which becomes mushy just before final solidification in effervescing steel. These are manifestly caused by a different gas from that which causes the skin and intermediate holes, and as ammonia is a normal constituent of gases in the central part of a steel ingot it is presumable that that gas, together perhaps with some nitrogen and, it may be some residual CO, causes and fills the central holes. These holes are not important nor harmful. Central holes are not exactly alike in their modes of occurrence in both effervescing and partly killed steels. In the former they are spread at random over a larger part of the section of the ingot, while in the latter they are located near the pipe cavity in the upper central part of the ingot. With a profusion of skin holes the central holes are few in number or even absent which indicates that CO may be a normal constituent of the gases they contain. Sections and analyses of partly killed rail ingots have shown that central holes in such steel accompany marked segregation of carbon and phosphorus in the upper central part where the holes were most plentiful. Without one of these the other did not appear. These ingots when containing about 0.12 per cent of silicon usually have a belt of skin holes around their upper half or quarter, presumably formed by hydrogen, and a cluster of central holes around the central pipe and settle holes. Intermediate CO holes are usually absent. Such steel does not rise in the molds. The silicon added seems to decompose the CO and, together with a ferrostatic pressure of four or five pounds to the square inch to hold the hydrogen in solution so that the lower half or three-quarters of the ingot is sound. In the upper part of the ingot where the pressure due to the metal head is less, some hydrogen is released from solution to form skin holes. More silicon, aluminum or titanium added would keep the hydrogen dissolved in the metal and, of course, give a larger pipe. This partly killed steel may have been cast at a proper temperature, its gas holes being the natural result of the practice by which it was manufactured.

The pipe cavity of an ingot, if airtight, probably always contains inflammable gas and under pressure which shows that it has collected in part at least in the hole after the steel solidified and while it was cooling as otherwise a partial vacuum would exist in the cavity. Talbot found the part of this gas insoluble in water to be about 90 per cent hydrogen and the remainder mostly nitrogen, within one case 5 per cent of CO when the top of a large ingot of solution steel 10 tons or more in weight, is broken off by deep grooving in a lathe followed by a heavy blow, the gas in the pipe cavity thus released is often ignited by sparks caused by friction of the separated parts and burns with a slightly luminous flash of flame.

Fourth of Class III are nitrogen bubbles, which are the remains of air bubbles mechanically entangled in freezing steel. These are rare in ingots, but sometimes exist in castings. The oxygen which accompanied the nitrogen exists as CO in the hole, also as it is insoluble in the metal. These air bubbles are located at random, due to the way the air entered the metal. They can only occur in an ingot which was cast too cool or they would have risen to the top when carried under by the stream. Such an ingot would probably have wrinkles and cold shuts anyway which would without the air bubbles send it to the scrap heap. In castings, such bubbles may occur from air entrapped in a too impervious mold.

Fifth are hydrogen and CO holes, which are caused by steam bubbles which in some way have got into the steel and been decomposed by the carbon. They occur only in castings, the steam forming in the sand beneath and rising into the still liquid metal and being entrapped there. They are likely to be found, if at all, where some recess on the lower side catches the steam, and in castings made in green sand which, of course, contains considerable water.

Sixth are holes formed by bubbles of hydrocarbon gases, which result from the destructive distillation of organic matter in the molding sand by the heat of the metal. These gases get into steel castings sometimes when the mold is not properly vented and when the design of the casting is such that a pocket or recess exists on its under side, as in the fifth variety mentioned above. The heavier hydrocarbon gases may be chemically cracked by the heat, the liberated carbon entering the metal leaving only light gases in the hole.

The gases of the fourth, fifth and sixth varieties of Class III may make defects of almost any shape, as well as bubbles, which defects may be open to the air. They are the gases which sometimes make real blowholes. When they form gas holes within the metal a partial vacuum exists in each hole due to the high temperature followed by cooling.

Holes of the first three varieties probably grow in size from their first beginnings in the solid or near-solid steel until the strength of the metal has become great enough to resist the pressure of the separating gases and so prevent their further growth. The exudation of gas into them may continue, however, until a pressure is reached in each sufficient to prevent further escape of gas into it. This, as we have seen, may take place at a pressure of 600 pounds per square inch.

The intermediate and central holes form in plastic metal of rather uniform consistency, cooling at a nearly uniform rate in all directions. They are, generally speaking, more nearly spherical in shape than are the skin holes.

The occurrence of ammonia in steel was first brought to my attention nearly 40 years ago by a mechanic who regularly rough-turned large steel forgings, mostly shafts, who asked me why we put hartshorn in our steel. Full of skepticism, I questioned him about it, and he maintained that he often smelt it coming from the steel, which was Siemens-Martin steel melted in a 10-ton acid furnace by the pig-and-scrap variation. The bath was formed of pig iron and steel scrap, charcoal direct iron blooms being added hot to work out and dilute the carbon. No ore was used. The slag was usually viteous, of olive green color, when in a thin cold layer. He promised to send for me the next time he noticed heartshorn, and soon after did so, and I distinctly smelt ammonia gas coming from the center on the end of the forging. He further said that the escape of ammonia showed that there was a hole in the forging and that proved to be the fact when the knob left on the end of the rough-turning operation and containing the "center" was broken off with a sledge to permit recentering. This hole was a small, ragged pipe, probably due to or increased by forging with a too-light hammer. A fine wire could be run in about two inches and the cavity doubtless ran in much deeper. The machine-shop foreman further told me that he had had one case where the hartshorn gas escaped with an audible hissing sound with force enough to blow chips off the centering drill and in quantity to bring water to the eyes of the men nearby. I have since then met a number of men who knew of ammonia in steel, and several years ago Wickhorst noticed it in some Bessemer rail steel ingots which were split in two longitudinally, stating that "when broken these ingots gave off the odor of ammonia from the fracture and also turned phenolphthalein red." This change of color is due to alkaline reaction. Each ingot had an imperfect pipe and a number of central gas holes which were doubtless filled for the most part with ammonia.

Steel, which has been subjected to abnormal treatment, may contain holes not readily classified. Thus a heat of electric steel which, through an oversight was kept molten and extremely hot over night, made unsound ingots having gas holes which ran through the metal like worm holes through wood and were not to be recognized as any familiar kind.

Gases Which Remain Dissolved in Cold Solid Steel.

Some investigators have thought that they detected some effect from hydrogen or from nitrogen contained in steel, but the cases can hardly be considered as proven. Any hydrogen in the metal must probably be present in solution and in extremely small proportion by weight. Any nitrogen present is either in solution or combined with iron. Both these gases if present in elementary form must evidently be set free when the metal is dissolved as by an acid, but Prof. E. D. Cambell's results do not indicate any notable volume of either. The way in which silicon alluminum and titanium holds hydrogen from forming bubbles in solution steel, and from reappearing when the steel is dissolved, remains unexplained. This is, of course, assuming that Prof. Cambell tried solution steels.

Gases Which Are Evolved from Heated But Not Molten Steel.

A number of investigators have extracted gases from steel by heating it in a vacuum and have analyzed them. They were chiefly carbonic oxide and hydrogen and the quantities were from 6 to 13 volumes of the steel. The CO must seemingly be formed as it appears by the combination of carbon with oxygen in the metal and the hydrogen be released from weak combination or solution by taking away atmospheric pressure. Cast iron yielded much less gas than steel, under two volumes, which agrees with, though it does not explain the gas-dissolving power of the blast furnace ferrosilicon previously mentioned. The study of these gases does not aid the metallurgist much as his treatment of and trouble from gases all happen while the steel is fluid or nearly so.

Gases Which Are Evolved When Steel Is Dissolved.

Prof. Campbell, as already stated, has opened up this field of research which is full of interest and promises, when more fully explored to throw much light on the constitution and gases of steel. He found that one grain of pure iron evolved 400 cc of hydrogen when dissolved in acid, that being the theoretical amount. Ordinary simple steels yielded from 360 to 390 cc of mixed steel to pure iron the greater the volume of gas. One grain of pure carbide of iron yielded from 250 to 253 cc of a mixture of hydrogen and a large number of hydrocarbons. Hardened steel gives more gas than unhardened, the hydrocarbons evolved being lighter and therefore more voluminous. He found that lower mean molecular weight of hydrocarbons evolved results from:

1. Higher carbon in the steel.
2. Higher degree of hardening impaired to the steel.

His results indicate that the amounts of hydrogen, carbonic oxide and nitrogen in solution in the steels examined were very small if indeed any were present, assuming that they would have been set free when the steel was dissolved.

The effect of exposing heated steel to hydrogen, ammonia, carbonic acid and nitrogen have been tried but without results.

(Continued on page 197.)

The Manufacture of Wire Rope

A General Description of the Machines and Operations Involved in the Manufacture of Wire Rope at the Palmer Plant of the Wickwire Spencer Steel Corporation.

By CARL KING,

Wickwire-Spencer Steel Corporation.

WIRE ROPE is made by twisting into strands and then twisting the strands into rope. The machines which twist the wires into strands are called stranding machines and the machines which twist the strands into rope are called layers. The size of the machines depends upon the size of the rope.

The wire as it comes from the testing room or stock room is first spooled upon steel spools of from four to five hundred pounds capacity. This is done in order that the machines may not have to be stopped too often to braze the wires together as well as for reason that it is necessary for the wire to be placed in the machine in such a position that it may be drawn out easily and evenly.

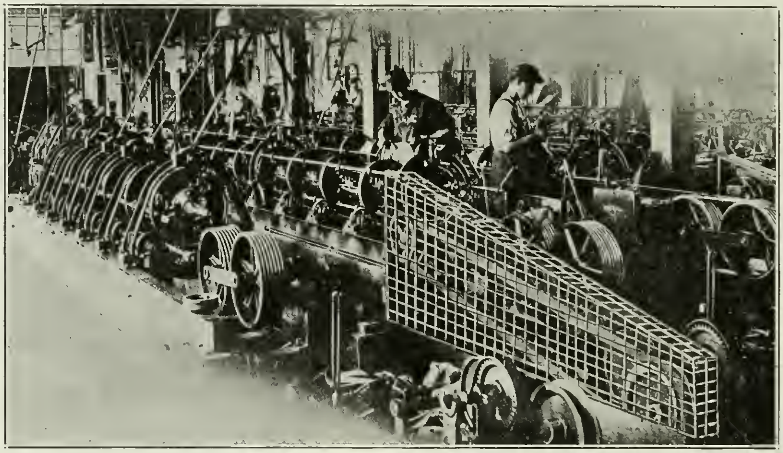

Fig. 1—Stranding machine.

Figure 1 shows a group of stranding machines. The man on the second machine is placing a full spool of wire in the cradle of the machine. The cradle, which is suspended between the discs of the machine, holds the spool and allows the wire to be drawn out evenly under a steady tension produced by a cord running over a groove in the spool.

The stranding machines shown in figure 1 are of the Smith, or English type. In these machines the wires run from the spool through the disc and from here to a sheave on one of the pipes on the machine. These pipes keep the discs the correct distance apart and the whole machine is tied together by rods running through the pipes. The wire runs along the pipe until it gets to the front of the machine, here it passes over another sheave and goes to the head of the machine.

The twisting head of the machine contains as many slots and holes as there are wires in the strand. There is always one center wire which goes through the center of the head. This wire runs straight in the strand and as the machine revolves the outer wires are twisted around the center wire.

The speed of the machine depends upon the size of the machine which, in turn, depends upon the size of the wire in the machine.

The wires, after being twisted in the head of the machine, pass around two drums which are geared to the machine. These drums are plainly shown in the foreground of figure 1. The machine runs at a constant speed and the speed of the drums can be changed to suit the size of the strand. The "lay" of the strand, which is the length of strand pulled out in one revolution of the machine, is determined by the change gears used in the train of gears connecting the machine and drums. The faster the drums revolve the greater will be the lay.

The strand, after passing around the drums several times to prevent slipping, passes to a large steel spool, which is driven by a friction drive with enough tension to keep the strand tight upon the drums of the stranding machine.

Another machine used is a large planetary machine. This machine derives its name from the motion in the back which keeps all the cradles in a horizontal position, thus preventing the wire from being twisted. The head and drums of this machine

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From Triangle Clan.

are the same as those of the Smith, or English type of machine.

The machine shown in figure 3, is a vertical layer. The strands which are made in the stranding machine are "laid up" in this machine. The principle of this machine is the same as the planetary machine, except that it is a vertical machine instead of a horizontal machine. It has eight large spools, all eight of which are used in making an extra flexible hoisting rope. For a regular hoisting rope of six strands, only six spools are put into the machine.

The six or eight strands which are laid up in this machine are laid around a manilla center. This manilla center acts as a cushion for the strands. This center is lubricated as well as the strands.

The simplest rope to make is the 6 x 7 construction. This rope is used for haulers, sand lines and standing or guy rope. As there are only forty-two (42) wires in the rope, the rope is stiff and is not easily bent around sheaves unless of very large diameter. This construction is always used to guy up derricks; and when exposed to the weather is galvanized. Figures 6 and 7 show a rope of this construction.

The rope most used as a hoisting rope is the 6 x 19 construction shown in figures 4 and 5. There are 114 wires in the rope and it is consequently much more flexible than the 6 x 7 construction rope of the same size, due to the smaller wire. Since the wires are smaller it is possible to use the rope on much smaller sheaves than a rope of the 6 x 7 construction.

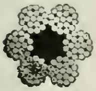


FIG. 4

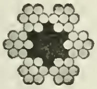


FIG. 6

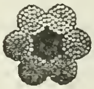


FIG. 8

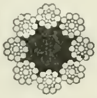


FIG. 10

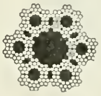


FIG. 12

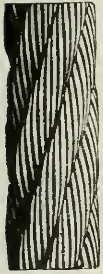


FIG. 5

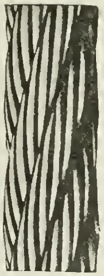


FIG. 7

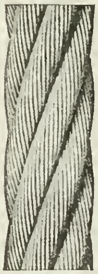


FIG. 9

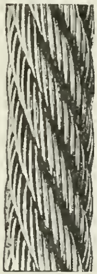


FIG. 11

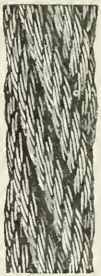


FIG. 13

For ropes which must be used on small sheaves, such as crane ropes, the 6 x 37 construction shown in figures 8 and 9 will give good satisfaction. These ropes are made of small wires and will therefore stand but little abrasion. This is called special flexible hoisting rope.

Extra flexible hoisting rope composed of eight strands of 19 wires each is about as flexible as the special flexible rope, but is not as strong. This decrease in strength is due to the larger hemp center.

Another construction, shown in figures 12 and 13, used for hand ropes on elevators and other places where the most flexible rope is required, is called tiller rope. This rope is made by taking six small ropes 6 x 7 and laying them up once more in a 6 x 6 x7 rope. The wires in this rope are very fine; the indivilual wires in a one-fourth diameter tiller rope being only .009 inch.

There are various other constructions for different purposes, but the above are the most common constructions.

Figures 10 and 11 show the construction of a 6 x 19 Seale style rope. This rope differs from the 6 x 19 shown in figures 4 and 5, in that although it has 19 wires in the strand, the outside wires are larger than the other nine wires yet they are not as large as the center wire. This construction is used on the Pacific Coast much more extensively than in the East.

Most hoisting rope today of the 6 x 19 construction is made of three sizes of wires. This allows about 10 per cent more material in the rope with the corresponding increase in strength. This type of rope is sometimes called "Warrington Lay."

Wire rope is made from wire of various kinds. The greater part of the rope is made at Palmer plant, Wickwire Spencer Steel Company, is made from steel of a tensile strength of from 180,000 pounds per square inch to 260,000 pounds per square inch. Every coil of this wire is tested on both ends and if it is not up to the required standard, it is rejected.

For guy rope, running rope and hawsers, the wire is galvanized.

GASES OBTAINED IN MOLTEN STEEL.

(Continued from page 195)

The work of the different investigators of the subject cannot be correlated partly because necessary particulars of the steels worked upon are not given.

Conclusions:

The most harmful gas holes in steel are the skin holes, which are caused by hydrogen.

Silicon, alumnium and titanium have power to keep hydrogen in solution in steel when it freezes.

Silicon aluminum and perhaps titanium have power to decompose carbonic oxide at ordinary steel casting temperatures.

Carbonic oxide is either evolved or in gas holes or is decomposed by the final additions.

Manganese has power to decompose carbonic oxide at an unduly high casting temperature.

Manganese has little or no power to keep hydrogen in solution.

Gases are probably of but little importance in cold steel except when they form gas holes or other structural deffects.

WILL REBUILD TWO STACKS.

Plans have been completed by the Wheeling Steel Corporation for rebuilding and remodeling its No. 1 La Belle stack, Steubenville, O., and its Martins Ferry stack at Martins Ferry, O. Improvements at the La Belle furnace will include the enlargement of the stack for increased capacity, relining the hot blast stoves and the installation of a new gas cleaning system complete with new uptakes, downcomers, a dust catcher and a gas washer of the Brassert type.

Direct Recovery Process for Flue Dust

Blast Furnaces Find This Process to Be One of the Most Economical—First Cost of a Direct Recovery Plant Smaller Than That of Any Other Process—Operating Expense Also Very Low.

By GEORGE B. CRAMP,
Engineering Department, Carnegie Steel Company, Clairton Works.

WITH a plentiful water supply available, other considerations in connection with the installation of a wet washing system for cleaning blast furnace gas, and incidentally a flue dust recovery system, are:

First—Dry dust catchers for receiving and holding the heavier dust particles such as are carried by the gas from the furnace under normal working conditions, and also the bulkier coke, ore and limestone stock thrown from the furnace during a slip.

Second—Wet gas scrubbers, or washers for washing out of the gas all dust remaining therein after having passed through the dry dust catcher.

Third—Disposal of the dirty wash water from the gas washers or other apparatus in which the water has been used in any manner to wash dust from the gas.

Fourth—Recovery and treatment of the wet dust from the wash water, along with the flue dust recovered in a dry state from the dry dust catchers.

Fifth—Method to be used in recharging the recovered flue dust into the blast furnace.

Consideration of the foregoing will be taken up in their respective order in that part of the discussion immediately following, with a view to outlining present practice on the subjects involved, pointing out imperfections and suggesting improvements thereon, with the further object of accomplishing a co-ordinated arrangement of improved apparatus which will satisfactorily and effectively recover and recharge into each individual furnace practically all flue dust produced by that furnace, at the furnace site, and accomplish this direct recovery of flue dust automatically, continuously and without labor or transportation cost, and with a minimum water and power requirement.

Though practice at various blast furnace plants differs as to the number and size of the dry dust catchers used, there is but slight difference in their design. They are usually of cylindrical shape with inverted conical bottom which forms a hopper for the dust and larger stock deposited therein. The top is usually dome or conical shape and the downcomer or downcomers, which conduct the gas from the top of the blast furnace, enter through the top or the side of the dust catcher. The gas outlet connection may occur at either place, but preferably opposite, or as far from the inlet or downcomer connection as possible. There is but little advantage gained by either arrangement, however, as the amount of dust precipitated in the dust catcher varies in accordance with the velocity and dust content of the gas passing through it, and the larger the dust the lower the velocity of the gas moving through it and the greater the dust precipitation therein.

Not much has been done toward accomplishing anything within the dust catcher other than possibilities in the economic handling of flue dust if designed s a separator for separating flue dust from the larger coke, ore and limestone stock discharged from the furnace during a slip. Separation of these grades would permit the fine dust to be sluiced or flushed out of the separator with the same water that is previously used to wash the gas in the wet gas washer thus accomplishing combination of all flue dust and necessitating but one method of handling thereafter. The larger stock brought down within the separator is freed from dust and held within the separator until drawn off into cars and taken to the ore, or coke bins to be recharged into the furnace.

The improvements in dust catcher design just proposed are met in the design shown in the drawing of the direct recovery process and described later.

The first and greatest saving in cost of handling flue dust and recovery of bulkier stock is possible of realization in this improved design, which may be termed the most vital of any of the improvements proposed, as it predetermines the extremely simple methods of handling the flue dust in wet form made possible by the separating and dust flushing features of the design.

At some plants further efforts are made to precipitate dust in the dry state, between the dry dust catcher and the wet gas washers, by installations of secondary dust catchers, dust legs or pockets and dry whirlers; all of which catch some dust as the gas passes through them. This would occur, however, if an almost infinite number of pieces of apparatus were used to recover the dust in a dry state, and it is for this reason that recent practice has inclined toward the omission of all dry dust catching devices between the first dry dust catcher and the wet gas washer, and installing the gas washer as close to the dust catcher as possible so that the connecting gas main may be shortened to the minimum and otherwise arranged to be self-cleaning, in that no dust will find a lodging place throughout its length.

Wet gas washer design has in the past covered widely different views on various types of apparatus for accomplishing the washing of dust from blast furnace gas, using water as the washing medium. All these types of washers may be roughly arranged into two groups, namely, power driven and stationary washers. Of the power driven washers the Theissein is a good example, and is one of the few designs of power driven washers remaining in practical use; and this for secondary, or final washing only, it being entirely out of consideration as a primary washer, or scrubber.

In the stationary group of washers the rain, or spray type, and the baffle types form two sub-divisions. By rain or spray type is meant those washers, or scrubbers, as they are more often called, wherein a rain, or spray, of water is dropped from a considerable height within a tower through which the gas travels upward, the dust carried by the gas being washed out by contact with the spray of water.

Within the baffle type washers, sprays of water are directed on baffles made of wood or metal, the surfaces of which serve to retard the fall of the water as it falls from top to bottom of the scrubber. The baffles are so arranged that they split up the gas body as it travels upward through the scrubber and causes the gas to come into more intimate and positive contact with the wet surfaces of the baffles on which much of the dust impinges and is then washed off by the continuous spray of water directed on them.

Of the two types of stationary washers just described the baffle type has proven to be of greater efficiency for two reasons: First, because in the rain, or spray, type scrubber there are usually heavier sprays of water required to break up the gas body and penetrate it. Gas in moving through a spray acts much like wind with rain in a storm, a strong wind often being seen to blow sheets of rain at a sharp angle to the perpendicular, and gas acts likewise in a spray type scrubber, except—that being confined within the scrubber—the gas tends to travel through the spray. Second, in a well arranged baffle scrubber channelling is practically eliminated as the gas is split up into thin bodies which are compelled to travel between two wet walls which prevent their surging, or channelling. A further advantage is gained by the baffles in that they retard the fall of water, thus bringing a given quantity of water into longer contact with the gas and causing it thereby to wash out more dust from the gas.

The nature and position of baffles within a gas scrubber are determined by simple considerations; for example: If a wet board or sheet of metal one foot square is projected into a moving body of dirty gas, with its greatest area at right angles to the direction the gas is moving, it will be found to pick up no more dust from the dirty gas than if turned 90 degrees to the original position, while the resistance to the moving body of gas—with the baffles in the first position—would be much greater. It is for this reason that baffles are set edgewise or parallel to the direction of gas flow.

After exposure of one square foot of wet baffle surface to a body of dirty gas in the manner just described, it will be found to have collected a certain amount of dust in a given length of time. If twice the area of baffle surface is exposed to the dirty gas about double the amount of dust will be collected, and by provision of ample baffle surface a given volume of gas—of given dust content—is continuously cleaned or washed of dust by the action of the water spray directed on the baffles.

In the selection of materials for baffles, wood is usually chosen, mainly because it is cheaper material and because it can be readily built into the scrubber. Wooden baffles, however, have some serious disadvantages. One of these is the bulk of the wooden baffle, which is usually about an inch thick, and as the spaces between the baffles cannot be much less than an inch, because of the tendency to warp and thus close the openings between them, it is readily seen that baffles of wood occupy one-half of the cross sectional area of the scrubber in which they are placed, and on this account a scrubber shell of twice the diameter is necessary than would be required if thin plates or sheets not over 1-32-inch thick were used. This is a very serious consideration when arranging spray water distribution, as the area over which a given quantity of water is to be sprayed, is about twice as great with wooden baffles as would be required with thin sheet baffles.

A further objection to wooden baffles is their liability to being over-dried and warped if the water should go off the scrubber while in operation, while at least one instance is known where the baffles have taken fire during construction, causing the scrubber shell to buckle badly.

After having been washed by contact with wet baffles and spray, the gas has been cooled and cleaned of practically all dust, but on leaving the scrubber it carried with it considerable entrained moisture in the form of fine water mist, which has been picked up and carried along by the gas as it moves out of the scrubber at high velocity. It is, therefore, very desirable to remove this moisture, if possible, within the scrubber, and it is possible to remove much of this moisture by causing the gas to impinge on baffle surfaces not sprayed constantly with water. The moisture in the gas coming in contact with the baffle surfaces gathers on them, and, forming in drops, trickles down and off the baffles. For removal of moisture from gas in this manner the wooden baffle is not well suited because of its bulk, and as the drying area is necessarily considerable it would be impractical to consider this construction within a scrubber.

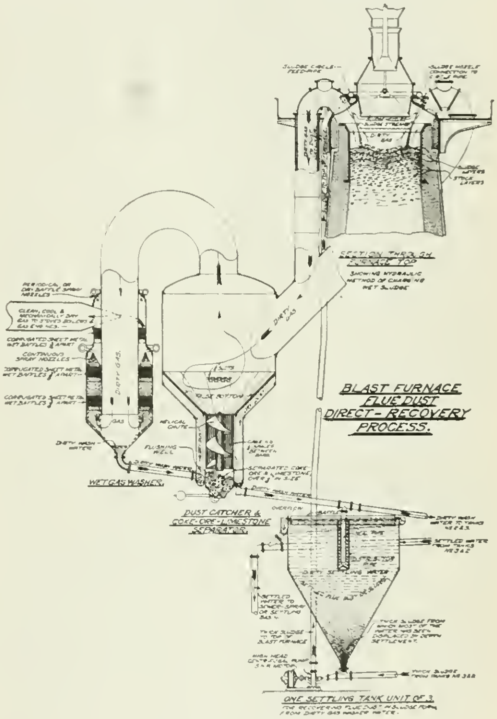

BLAST FURNACE FLUE DUST DIRECT-RECOVERY PROCESS.
SECTION THROUGH FURNACE TOP
SHOWING HYDRAULIC METHOD OF CHARGING WET SLUDGE
DIRTY GAS
CLEAN, COOL & MECHANICALLY DRY GAS TO STOVES BOILERS & GAS ENGINES.
CORRUGATED SHEET METAL WET BAFFLES ⅛ APART
CONTINUOUS SPRAY NOZZLES
DIRTY GAS.
GAS
DIRTY WASH WATER
DUST BOTTOM
HELICAL CHUTE
FLUSHING WELL
SEPARATED COKE ORE & LIMESTONE OVER ⅛ IN SIZE
WET GAS WASHER.
DUST CATCHER & COKE-ORE-LIMESTONE SEPARATOR.
OVERFLOW
BAFFLE
SEAL PIPE
DISTRIBUTOR PIPE
DIRTY SETTLING WATER
SETTLED WATER TO SEWER-SPRAY OR SETTLING BASIN
THICK SLUDGE TO TOP OF BLAST FURNACE
HIGH HEAD CENTRIFUGAL PUMP
ONE SETTLING TANK UNIT OF 3.
FOR RECOVERING FLUE DUST IN SLUDGE FORM FROM DIRTY GAS WASHER WATER.

Fig. 1—Direct recovery plant.

Further consideration of these points of design are taken up later in the description of the gas washer, as represented in the accompanying drawing.

Probably as great, if not a greater problem, than that of gas washing itself is met with in considering proper methods for the disposal of dirty water from the gas washer. Government restrictions have in the past and will in the future, make it more imperative that water after using in blast furnace gas washers be first settled in properly constructed tanks, basins, or ponds of sufficient size to accomplish the retention of most of the dirt from the water before it is turned into public water courses where it rapidly clogs or obstructs the channels, the yearly deposits from a one-furnace plant alone being enormous.

From an economic viewpoint it is even more important that the gas washer water should be made to yield up its valuable burden of latent raw material. Several different designs of settling basins are in use, in most cases it being the practice to divert the water from all scrubbers to one basin, and for this reason the basin must be of such large dimensions as to necessitate its being located some distance from the furnaces, or scrubbers, in order to secure the space required for its installation.

The basin may be of single compartment construction or more usually of two or more compartments which permit of one being cleaned of the deposited flue dust sludge while the dirty wash water flows through the other. Cleaning, or dredging, is done with a locomotive, or overhead electric crane. A more recently developed design of settling basin accomplishes settlement and cleaning continuously in one circular basin, the cleaning being accomplished by use of a bottom scraper or plow mechanism, which works the sludge toward the center of the basin, from which point the sludge is then pumped.

At plants where it is the practice to recharge the wet sludge into the furnace, it would be a decided advantage to settle the dirty wash water in two or three tanks, the diameter of which need not be over 22 feet with a depth of 10 feet, to handle the dirty water from the gas washers of a modern furnace plant. Settling tanks of this size could, in most furnace plants, be located near the furnace. The tanks could be of deep conical bottom construction in which sludge could settle to considerable depth, and the greater the depth attained the more dense and less watery the sludge becomes. With this arrangement sludge at almost any desired consistency could be tapped off at the bottom of the tank and charged as desired.

Where it is regular practice to charge into the furnace all flue dust recovered in the wet form, and where it would be desirable to charge all dust produced, in the wet state, the problem is further complicated because of the dust, recovered in the dry state, which amounts to more than that recovered in the wet state. Dry dust at some plants, and both wet and dry dust at others, is transported to a sintering or briquetting plant, and after treatment, according to the process employed, the product in sinter or briquette form is returned to the furnace and charged in the usual way.

Consideration of either the sintering or briquetting processes for treatment of flue dust is obviated, however, if the flue dust is all combined and brought down in the wet form, as suggested in the foregoing, which leaves only the method of charging the flue dust into the furnace, open for consideration.

Where flue dust is treated either by the sintering or briquetting process, the method of charging is simple. The product from either plant is dumped into the stock bins at the furnace, where it is then charged into the stock larry car and thence into the skip car, as is all the coke, ore and limestone charged into the furnace.

Where all flue dust is to be brought down in the wet form, however, the method of charging is a matter of serious consideration. It has already been stated that at some plants wet flue dust is charged directly into the blast furnace without being either sintered or briquetted. This practice is not accomplished without considerable cost of hauling and other inconviences, and thus far no standardized system of handling or charging seems to have been developed.

At some plants both dry dust and all ore charged into the furnace are wet down with water just after being dumped into the skip car and before it is hoisted to the top of the furnace, where it is charged therein. An objection is always raised to this practice, however, because of the fouling effects of wet stock in the skip car and on the charging machine, but where the recovery of all flue dust in wet form is accomplished, as previously suggested, the charging of wet sludge is greatly simplified by application of the hydraulic system for lifting the wet sludge through a pipe to the top of the furnace where it can be easily distributed within the furnace through a circle pipe and specially designed nozzle which pierce the top cone of the furnace and introduce the sludge without bringing it into contact with any of the charging mechanism, accomplishing at the same time perfect distribution of the sludge, while the excess moisture in the sludge accomplishes a desirable wetting down of the other stock charged into the furnace in the usual manner.

The foregoing description of methods, practice and apparatus with suggestion for improvement therein, is based on actual operation, recent development, or experiment. The actual design of apparatus required to accomplish the suggested improvements, however, is represented in the accompanying drawing and described in the sequence of the order of their operation in the following:

The dust catcher shown is about of the usual design except that it has imposed about 18 inches above and inside its conical bottom a false conical bottom of plates having ¼-inch slots so arranged as to allow all fine dust and particles smaller than ¼-inch to pass from the upper to the lower chamber, which chambers are formed by the false bottom. The dust after passing through the false bottom drops into the true bottom of the dust catcher and slides thence into the dust flushing well where it is flushed out by the dirty wash water from the gas washer, which water has previously been used to wash out the remaining dust in the gas out of the gas washer.

Any particles brought down in the dust catcher that are too large to pass through the aforesaid ¼-inch slots in the false bottom simply slide down the false bottom into the helical chute in the bottom center of the dust catcher-separator. This helical chute is encaged in a cylindrical cage of bars with ¼-inch spaces between them. In ordinary operation this chute would not be required, but in cases of bad furnace slips, when tremendous quantities of coke, ore and limestone, with much fine dust, are suddenly thrown into the separator, much of the fine dust would remain unseparated except for the presence of the helical chute, down which all this stock must pass on being dropped out of the dust catcher-separator into cars in which it is carried to the stock bins. The chute inclines all material rolling down it against the encaging bars and the fines, or particles smaller than

¼-inch sift out between the bars into the flushing well.

By this separation much valuable stock is immediately made available for recharging into the furnace, and without cost for screening, or otherwise handling, except transportation to the stock bins. The fine dust separated within the separator is carried out of the flushing well by the water from the gas washer, thus eliminating all cost of handling and treating in the dry state.

After dropping much of the heavier dust in the separator the gas passes through a self-cleaning gas main into the gash washer. It enters through the drop leg of this main, which drops vertically into the center of the washer. The purpose of this construction is to accomplish perfect gas distribution on entering the washer and drop a great part of the heavier dust—still carried by the gas—immediately into the bottom of the washer. A further object is to permit of the washer being used as a water seal gas valve. By this arrangement the transverse sectional area of the washer is lost to gas cleaning to the extent of the transverse sectional area of the gas main dropping through it, but the thin corrugated sheet metal baffles suggested occupy so little of the transverse sectional area of the washer, effective for gas washing, that the shell diameter of the washer may be even less than scrubbers in which wooden baffles are used. Furthermore, the area over which water spray must be distributed is so much less than that of larger diameters that a material increase in gas washing efficiency is obtained.

On entering the washer through the open end of the drop leg of the gas main the gas turns an angle of 180 degrees and rises uniformily up through the torrent of falling water and begins to pass through the lower set of baffles, which are of thin corrugated sheet metal and spaced about ¾-inch apart, being held thus by simple indentations of the corrugations, which occur at odd points on the sheets.

In the first, or lower, baffles each cubic foot of gas is subjected to 80 square feet of cleaning surface, using a standard 2 feet 3 inches width of corrugated sheets, and the gas is thereby cooled and cleaned of the heavier dust. The dust, combining with the water flowing down the surfaces of the baffles, is continuously washed into the bottom and thence out of the gas washer.

Still rising upward, the gas passes through a second set of baffles similar in construction to those just described, but spaced ⅜-inch apart. Each cubic foot of gas in passing through these baffles is subjected to 160 square feet of additional cleaning surface and is here thoroughly cleaned of dust and cooled to within a few degrees of the entering wash water.

The gas travels through these baffles at about half the velocity it traveled through the entering main, but above the continuous spray nozzles shown on the washer the shell is contracted to a smaller diameter, which construction accomplishes the increase of the gas velocity to that of the entering main. As has already been described, this increased velocity of the gas accomplishes more forceful impingement of the water mist it has picked up in the lower part of the washer, against the dry, or unsprayed baffles set in this section of the washer. These baffles are spaced about 3-16-inch apart and each cubic foot of gas in passing through them is subjected to 320 square feet of drying surface. As the mist continues to impinge on the baffle surface it forms into drops and flows down their surface and into the lower part of the washer.

Cleaning, cooling and drying the gas of entrained moisture is in this manner accomplished in one piece of apparatus, thus providing gas, which may be carried through comparatively small unlined mains, to the stoves, boilers or gas engines. The compact baffle arrangement described permits of low wash water pressure by reason of the greatly reduced height of the washer accomplished by this design, further permitting the bottom of the washer to be raised to a level sufficiently high to permit of the dirty wash water flowing from the washer to enter the dust catcher-separator, where it picks up additional dust, and from thence to flow into the settling tanks.

Dirty wash water carrying all dust brought down in the gas washer and dust catcher is run by gravity—as just described—through straight pipes to the settling tanks, which for a modern furnace plan would be three in number and about 22 feet in diameter, or 20 feet square with a depth of about 10 feet on the sides, which would permit of their being located in line with and beyond the dust catcher in most furnace plants. The water enters the tanks through a seal pipe, which prevents gas at all times from escaping from the dust catcher with the water. The water passes out into the tank through a perforated distributing pipe and thence travels at an ever-decreasing rate to the side wall of the tank, where it overflows. In passing slowly through the tank about 90 per cent of the flue dust in the water is precipitated therein and settles into the steep conical bottom of the tank in the form of a silt-like deposit, or sludge. The water flowing over the weir wall of the tank drops into a trough running around the tank and thence flows through a pipe to the sewer, which may carry it to a nearby stream, settling basin, or spray pond if the same water is to be used over again.

As the sludge settles to the bottom of tank to increasing depths, water is, to a great extent, displaced by the pressure of the upper mass of material so that at the bottom of the tank, where it is removed through the sludge pipe, the sludge would, under proper working conditions, contain not much in excess of 25 per cent water, which would permit of its being immediately charged into the furnace.

The nature and consistency of the recovered sludge make it possible to charge hydraulically with a high head centrifugal sludge pump with a power requirement of not more than five electrical horse power running continuously.

The sludge is collected and pumped through comparatively large pipes to reduce abrasion. The sludge enters the top of the furnace through a circle pipe and specially designed nozzles connecting thereto and piercing the top cone of the furnace. The nozzle openings are flat and are of sufficient number to distribute uniformily a ring of sludge onto the stock just under the large bell. This sludge ring distributes itself over the stock and the new charges of stock are dropped in on the sludge layers. Excess moisture in the sludge is therefore rapidly absorbed by upper and lower stock layers, thus accomplishing a wetting down of all stock, thereby lessening dust production.

The advantages gained by this system of flue dust recovery are:

First—Separation of fine flue dust from the bulkier stock is immediately accomplished, and the large stock made available for charging into the furnace.

Second—The fine flue dust is flushed out of the dust catcher-separator continuously by the same wash water that has previously been used for gas washing.

Third—The gas is thoroughly cleaned, cooled and mechanically dried, and may be conducted through relatively small unlined mains to small checker stoves, boilers, or gas engines.

Fourth—The water used in the gas washer carries all dust from both washer and separator to the settling tanks where all but about 10 per cent of the dust is recovered from the water in wet form, thus eliminating all cost of handling and treating contingent on recovery of dust in dry form, or when recovered part wet and part dry.

Fifth—All dust recovered in wet form is immediately available for charging into the furnace, eliminating the necessity of treatment by either the briquetting, or sintering, process.

Sixth—Flue dust in wet, or sludge form may be pumped into the top of the furnace accomplishing the wetting down of all stock and consequent retention of much of the dust that would otherwise be blown out of the furnace.

Seventh—Recovery of flue dust is accomplished at each furnace making possible the recharging of the same flue dust produced by that furnace.

Eighth—The dirty gas washer water is sufficiently purified to permit of its being run into a public watercourse.

Ninth—Water, power, transportation, labor and operating costs for this recovery process are less than that of any other.

Tenth—The first cost of constructing a direct recovery plant is negligible compared to that of plants for treatment of flue dust by any other process.

Development of the Steel Industry During the War in Germany

A General Review Showing the Various Improvements That Have Been Made in the Different Stages of Steel Manufacture in Germany During the Past Four Years.

By HUBERT HERMANNS,
Special Correspondent, Blast Furnace and Steel Plant.

PART III.

A COMPLETE review of the development of the electric drive for rolling mills in Germany will be published in one of the forthcoming issues of this magazine. We will, therefore, at present, only review briefly the advantages adherent to the electric drive.

These advantages are:

1. The remarkably good regulation. This regulation permits the rolls to bite easily and then to increase the rolling speed quickly to a maximum and to furnish rolling with a zero velocity. On account of the uniform torque the rolling speed can be considerably increased, increasing at the same time the output.
2. The posibility to transmit the energy without losses by means of conductors, which can be laid easily, safely and cheaply.
3. Elimination of losses due to shut downs, combined with the possibility of starting operation on shortest notice.
4. Small space requirements for the motors.
5. Easy measurements of the power requirements, which, in many cases, allow to draw conclusions in regard to errors or to possible improvements.

All these advantages have made, up to the present time, the electric drive superior to the steam drive. But, nevertheless, it can hardly be expected, that, in the near future, the electromotor will replace entirely the steam engine. This is due to the fact that economical and technical conditions in the different rolling mills vary within wide limits, mainly in regard to the power consumption. But an increased introduction of the electric drive has a direct advantage in so far as the increase in electric power demand permits a better and a more efficient working of the power station and thus permits a cut in the power costs. It is true this means a saving for all electrically driven installations, but it is, originally, due only to the increased electrification.

The general trend of improvement was, as in other countries, directed towards an increase in tonnage and a most extended utilization of the plant; a decrease in labor in order to make the operating expenses as low as possible, and, lastly, a reduction in accidents. Heavy mills are easier to operate with these improvements in view than wire mills. The unit weights of the billets are comparatively small in regard to the large cooling surfaces, for this reason it is not possible, to use the transportation facilities of heavy duty mills directly, that means without charges, for wire mills. In the first place the traveling speed must be increased considerably, and then, they must operate as automatically as possible. This automatic operation should be extended to the heating furnaces from the time the billets enter the furnaces until they enter the rolls. These movements have been made automatic by changing the furnaces to suit conditions. At the end of the furnaces the billets, now heated to rolling temperature, fall upon the rollers, which carry them to the rolls.

On the guide mills proper the main point under consideration was the replacing of the hand operation by automatic appliances. Charging the passes by hand does not only require many laborers, but it is dangerous and even when employing skilled men the rolling speed cannot be increased beyond a certain limit. These difficulties have been eliminated by the introduction of the automatic guides patented by Schoepf. These guides connect not only two adjacent passes on one stand, but also the adjacent stands. When changing from the oval pass into the square pass, the round sections are turned 90 degrees, whereas square sections are turned 45 degrees. Other designs of automatic guides have, so far, not been employed extensively. As far as the other auxiliaries for wire mills are concerned, much time and money has been spent to improve construction and design of wire drum with automatic discharge, of conveyors for the removal if the finished products and of low runways to save space. Fig. 10 shows a wire drum of the latest design. The wire, coming from the mill, is lead by a piece of pipe into the space between the outer and inner drum, which latter is revolving continuously in order to prevent buckling and breaking of the wire. After all the wire is wound up the motion of the drum is stopped and the buckets, which have supported the wire, are pulled back into the inside of the drum, thus permitting the wire bundle to fall down. This operation is automatic and controlled from the mill pulpit, whereas the starting and stopping of the drum is done by a separate operator.

The most important influence upon the charges in the design of the wire mills came from the introduction of the continuous and the semi-continuous mills and from the application of the electric power. In Germany the arrangement, as shown in Fig. 11, was preferred, which is the so-called semi-continuous, or German design. Here the roughing mill is divided into two groups of four stands each. Between these two groups is the shear for cutting the billets, which is mostly built as a flying shear. Quick automatic service and operation is insured by rollers before the first group as well as between the two. The finishing mill is also subdivided into two parts, which run with different speed.

When the German type was developed it was done with the intention of increasing the tonnage of the finishing mill by increasing the rolling speed of the rougher, the old arrangement of the finishing mill being well adapted for handling the larger tonnage. The results obtained up to the present time have proven this assumption to be correct.

In America the purely continuous mill is more generally used. This has not met with good success in Germany. This is due, on the one hand, to considerations in regard to the available space, because continuous mills require long buildings, and, on the other hand, to the high first cost for such types of mills. But there is another reason, which is derived from the shape of the finished product. The wire coming from a continuous mill is not perfectly round. This last point is not of a high importance for plants which refine the wire themselves. This is the reason that the wire mill Eschweiler of the Gelsenkirchener Bergwerks-A-G., selected, as the only wire mill in Germany, the pure, continuous type, because they refine nearly all their output themselves. This mill consists of a primary mill with seven stands and of a continuous finishing mill with 10 stands. The capacity of the mill is 150 tons of wire in 10 hours.

In general, and assuming normal conditions, it must be said, that, for the German rolling mill industry, there is no necessity for the installation of continuous wire mills. The small labor expenses are more than outbalanced by higher first cost, higher power consumption and larger wear and tear. In regard to the output, there is no difficulty in obtaining the same tonnage on a semi-continuous as on a continuous mill.

As for any other type of mills, electric drive has proven to be highly economical and efficient for wire mills. This type is rather well adapted for the use of electric power, because it requires a high speed and it runs with a fairly uniform load. For this reason standard type motors can be used, built ruggedly, of course, to suit the heavy operating conditions.

The current for driving the wire mill motors can be dc current, but general conditions in the mills are more favorable to the use of ac current. For this reason dc motors are not extensively used for mill drives, although their speed can be easier regulated than that of ac motors. For pure wire mills with a limited rolling schedule ac motors with speed regulators may be dispensed with, but they are important for such wire mills which are also used as merchant mills.

The details of the motors for the second group of roughing stands (in the front) and of the finishing stand (in the back) of a modern wire mill are as follows: The available power is ac current of 3,100 volumes and 42.5 cycles per second. The mill consists of a primary set with three groups of continuous stands and a finishing mill. The first group of the rougher, with 16.4-inch roll diameter, is driven by a direct connected motor of 1,500 to 3,000 effective hp and 213 rpm, the second group of four continuous stand of 10.4-inch diameter is driven by a motor with 1,200 to 2,400 effective hp, while the finishing mill with six stands, having a roll diameter of from 9.8-inch to 10.8-inch, is driven by a motor of 2,400 to 2,800 effective hp and 638 rpm. The third group of the continuous rougher is driven by a motor of 2,200 to 4,400 effective hp and 213 rpm, which also furnishes the power for two three-high mills connected to the last stand.

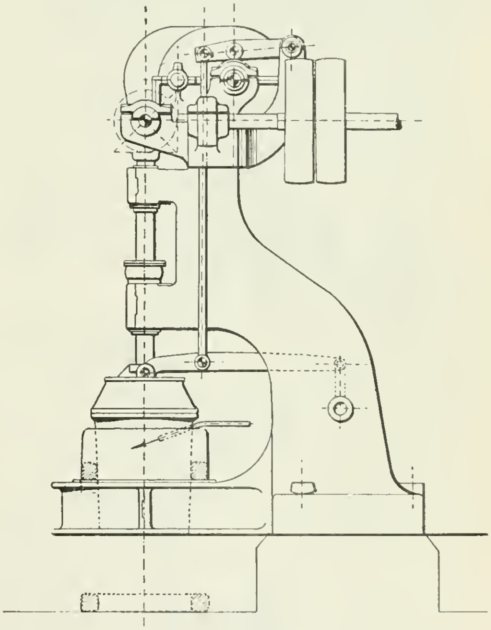


Fig. 10—Wire drum.

A few of the many and remarkable improvements of the electric drives for rolling mill auxiliaries may yet be mentioned. As a safeguard against a possible overloading of the motors, the fuses have been replaced by automatic circuit breakers, which prevent the loss of time due to a change of the fuses. These circuit breakers operate even when the engineer keeps the lever in closed position and intends to work with overload. The circuit remains broken, although the line connection may temporarily be cut out and thrown in again. When using controllers and copper switches, the automatic circuit breaker and the main circuit breaker are combined in an iron box, which, besides protecting the apparatus against dust, moisture, mechanical injuries, etc., has the advantage of preventing an unintentional touching of the charged parts.

The connection between the main circuit breaker on the pulpit with the power plant and the connection between the regulating apparatus and the motors is done by means of lead cables armed with flat iron. For the wiring on the pulpit connecting the different switches, controllers and resistances, high grade rubber covered and armored cables are employed.

The roll lathes require in the same manner as any other machine tools—drill press or ordinary lathe, a variation of the operating speed within wide limits and with very high exactness. It is very uneconomical, however, to obtain this result by means of bell cones or gear trains, but it can be easily obtained with a dc regulating motor, which is direct connected with the machine in question. It is built for rolls up to 40 inches diameter and for a maximum weight of 20 tons. The height of the checks is about 26½ inches and the distance between them about 20 feet. The speed can be varied by the motor between .5 and 30 rpm.

The other auxiliaries, such as saws, operating cylinders for adjusting the rolls, etc., are best and cheapest driven by dc current, even then, when for the rest of the mill ac current is supplied. This ac current can easily be transformed into dc current and used as such.

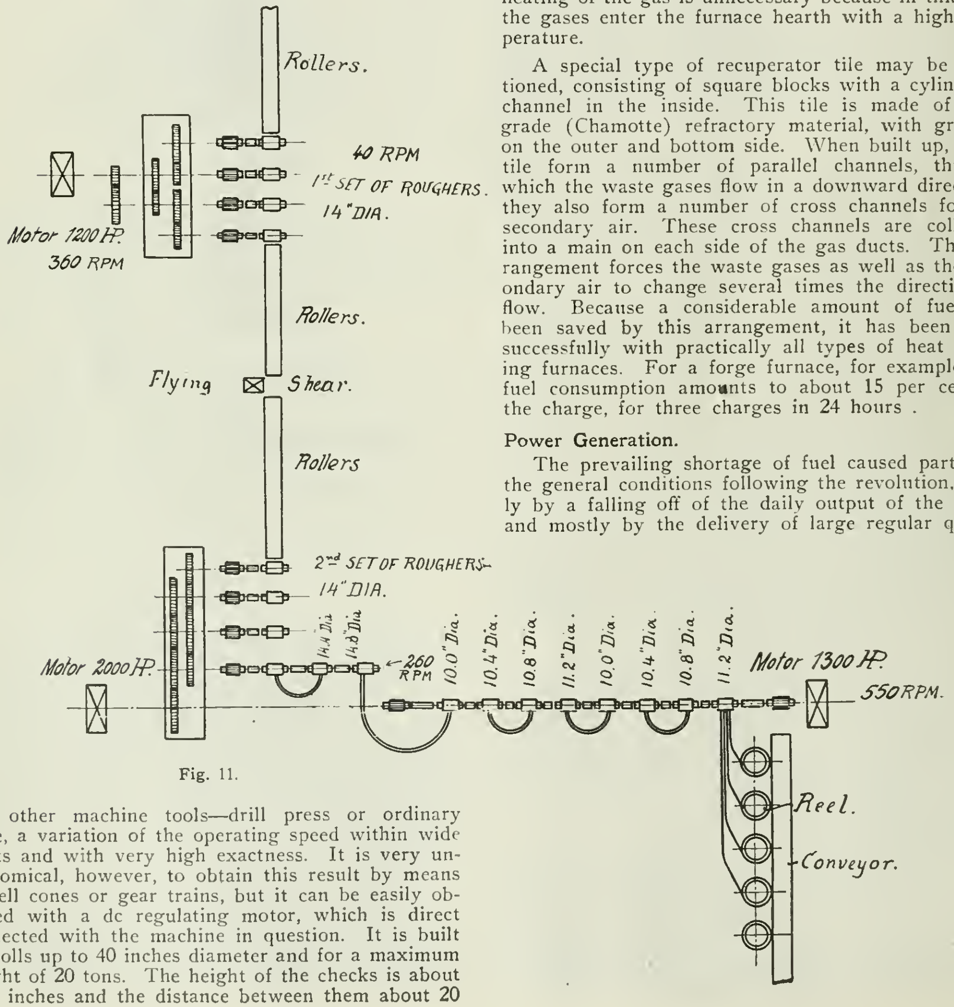


Fig. 11.

Heat Treating of Steel.

Apparatus for the heat treating of steel was designed with the view of increasing the output and of saving the fuel. The buck stays on the furnaces are arranged in such a way that the brickwork is easily accessible. The heat is utilized as much as possible by channels distributed around the brickwork and the waste gases are made to preheat the incoming air in a special type of recuperators. Wherever the producer forms an integral part of the furnace, preheating of the gas is unnecessary because in this case the gases enter the furnace hearth with a high temperature.

A special type of recuperator tile may be mentioned, consisting of square blocks with a cylindrical channel in the inside. This tile is made of high grade (Chamotte) refractory material, with grooves on the outer and bottom side. When built up, these tile form a number of parallel channels, through which the waste gases flow in a downward direction; they also form a number of cross channels for the secondary air. These cross channels are collected into a main on each side of the gas ducts. This arrangement forces the waste gases as well as the secondary air to change several times the direction of flow. Because a considerable amount of fuel has been saved by this arrangement, it has been used successfully with practically all types of heat treating furnaces. For a forge furnace, for example, the fuel consumption amounts to about 15 per cent of the charge, for three charges in 24 hours .

Power Generation.

The prevailing shortage of fuel caused partly by the general conditions following the revolution, partly by a falling off of the daily output of the mines and mostly by the delivery of large regular quantities of coal—according to the agreement of Spaa, 2,000,000 tons of coal per month—forced the industries to install aparatus which guaranteed a better utilization of the fuel, and allowed to use more low grade fuels.

It is not possible to enter into more details in this article and show all the numerous improvements which have been made in this direction. This will, however, be laid down in a later article, because many of these improvements are of high interest to the Amercian furnace engineer. Only a few installations for the unloading of railroad cars may be mentioned here.

The unloading of fuel as well as of other material on the railroads is done in Germany in entirely different ways than in America. In America automatic unloaders are used extensively, whereas the German railroad cannot apply these machines, because, in the first place, the road beds are not heavy enough for large weights, and in the second place, excessive changes, involving large sums of money would have to be made. It is true, experts have pointed, for many years, to the necessity of improving the heavy freight traffic, and chiefly the heavy industries have made many proposals, which may lead to improvements. The practical results of this work, however, were proportionately small. The railroad administrations, which are, as is well known, in the hands of the government, have permitted the use of some automatic unloaders, wherever the distance between the ore or coal mine and the blast furnace is short. But this permission favored only a few plants; the rest of the industries have to look out for themselves, when they desire to reduce their transportation costs.

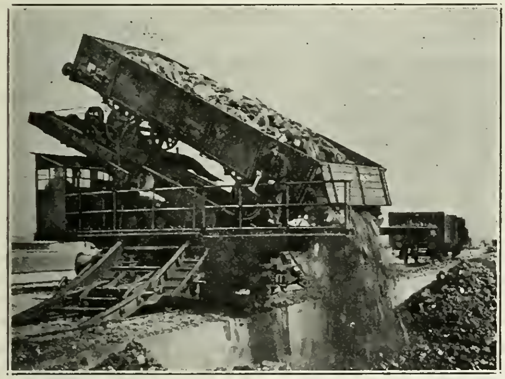


Fig. 12.

Necessity forced the development of automatic car dumpers to such a degree that, at present, they are highly efficient in all directions. This development was possible, because, in Germany, the open freight cars have doors on the two ends, through which the material is unloaded. The dumpers are mostly built stationary and can, for this reason, be uesd only at a certain place. If, on the other hand, material is to be unloaded at different places, stationary car dumpers can not be applied on account of their high first cost. This difficulty has been overcome by the design, shown in Fig. 12, which illustrates a traveling car dumper.

When designing this device, it had to be kept in mind, that the dumper is to be taken from one place to another, and for this reason, it has to be built in such a way that it could be coupled to a regular train between other cars. The tracks on each end of the dumper are, therefore, arranged in such a way that they can be lifted up and the movable platform can be locked. In this condition the dumper can be handled like an ordinary car.

The manner of operating these car dumpers is as follows:

The car which is to be unloaded is brought to and on top of the dumper by means of a revolving rope drum; it is then turned 90 degrees and dumped to the one side. The efficiency of this dumper is very high. Twelve cars of 15 tons each can be unloaded per hour.

For small tonnages another device has proven to be efficient during the last few years. This device consists of an elevator, which is suspended from a central shaft around which it can revolve. A shaft on the lower end contains a spital on each side, which force the material into a bucket conveyor. Similar contrivances have rendered good service during the war, when many plants had to store in the summer time large quantities of coal for winter use in a relatively small space.

ELECTRICAL ENGINEERS DISCUSS ECONOMIES.

Examples of large combustion losses in modern steel making featured addresses and discussion at the monthly meeting of the Chicago section of the Association of Iron and Steel Electrical Engineers, held at Hotel Morrison, Chicago, on February 19. The meeting followed a campaign for new members which practically doubled the enrollment of the section, 60 new names having been added to the list. The occasion was special in the sense that E. S. Jeffries, electrical engineer Steel Company of Canada, national president of the association; J. F. Kelly, national secretary, and A. H. Schwartz, Iron & Steel Equipment Co., Pittsburgh, chairman of the national program committee, were present.

Papers were read by John Sullivan, assistant superintendent Bessemer plant, Wisconsin Steel Works, on the Bessemer process of steel making, and by F. Von Schlegell, president Industrial Electric Furnace Company, Chicago, on the field of the electric furnace, particularly in the castings industry. Among those who participated in the discussion were H .J. Freyn, Freyn, Brassert & Co., Mr. Jeffries and Gordon Fox, electric engineer of Freyn, Brassert & Co., and chairman of the Chicago section of the association. Mr. Jeffries, in speaking on the subject of economies, cited what had been accomplished with the McCune type of open hearth furnace. Ordinarily it takes 8,000,000 Btu. to make a ton of steel in an open hearth, whereas in the McCune furnace only 4,000,000 Btu. are required. The average life of an open hearth furnace is 300 heats, whereas a McCune type furnace will yield 700 heats, he said, before it has to be relined.

It was announced at the meeting that the next annual convention of the National Association will be held at Chicago in September on dates as yet unfixed.

Heating Furnaces and Annealing Furnaces

A Critical Comparison of the Different Types of Furnaces in Use for the Heating of Heavy Forging Ingots.

By **W. TRINKS.**

PART XXVII.

THE present installment deals with a critical comparison of furnaces which are used for heating forging ingots and blooms or for heating partly forged pieces.

A factor which greatly influences the method of heating is the allowable rate of heating. In part II the reasons for the rule "20 minutes per inch of diameter in soft steel" and "30 to 40 minutes per inch of diameter in alloy steel," were explained, and in part XXVI, the temperature differences existing in the interior of the steel which is being heated at different rates were given numerically. In order to apply that knowledge to the problem in hand, it will be advisable to remember that steel which is heated too quickly shows internal cracks and fissures in the forgings quite aside from those which are due to gas occlusions in the ingot, or to defects in pouring practice or in shape of ingot. The larger the ingot, the greater is the temperature difference between surface and center for a given heating time. In consequence small bars and billets can be placed in a hot furnace without damage, while the same treatment injures large blooms or ingots. A further consequence is that in-and-out furnace containing three or four ingots cannot be charged again immediately after the removal of one of the hot ingots. The furnace must be emptied and cooled before it can be charged again with cold ingots, unless the latter are preheated. The immediate result is that any good size steam hammer or press must be fed by at least two furnaces so that one may be heating up while the other is being emptied. Often three furnaces are used. The type of furnace referred to here is illustrated by Fig. 202.

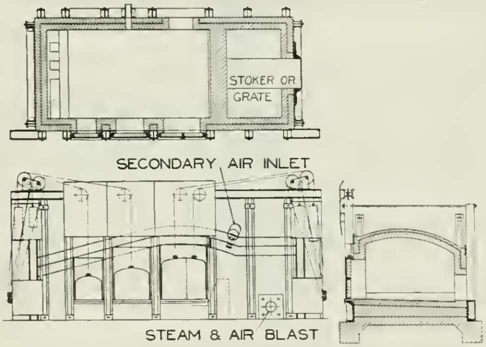


Fig. 202.

The furnace as well as the method of using it is simplicity itself, but the fuel consumption is outrageously high. More fuel is required to heat steel in this type of furnace than is required to melt steel in the open hearth furnace. The addition of a preheating furnace solves some of the difficulties, but lets others remain. If the preheating pit is separately fired, the only advantage by its use is that an ingot can be taken from the pit and can be put into the hot furnace in place of one which has just been taken out. That advantage is not cherished by the heaters, because of the radiation from the hot furnace, which is particularly annoying, while the opening on both sides of the tongue hold is being closed by brick and fireclay. As far as I know, there exists today no satisfactory way of closing the opening at the sides of the ingot. The furnace men prefer to build up the bricks in the opening while the furnace is cold, or else, if ingots are to be put into a hot furnace, to shove them all the way in and to close the door all the way down. The latter method necessitates the use of a manipulating device which lets go of the ingot after it has been laid down in the furnace and which, later on, grabs hold of the heated ingot without loss of time and without exposing the heater to the intense radiation of the furnace. And it also necessitates the use of sink heads of the same size on all ingots, or else interchangeable jaws on the manipulator head to fit different size sink heads. There is plenty of room left for inventive genius to devise ways and means for closing the openings below the door and at the sides of the ingot, when the furnace is at a temperature of 2200 degrees F.

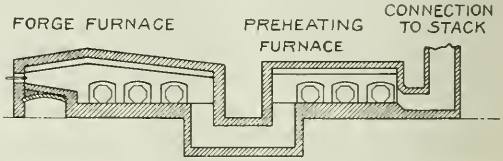


Fig. 203.

If a preheating furnace is attached to the main furnace, and is heated by the waste heat from the main furnace, see Fig. 203, the fuel consumption per ton of ingot heated drops considerably. The arrangement might appear ideal because of the lowered fuel consumption, and because the preheating positively prevents internal cracks and fissures in the forgings. But there are practical difficulties. First, there are all of those difficulties which were mentioned in the preceeding paragraph with the

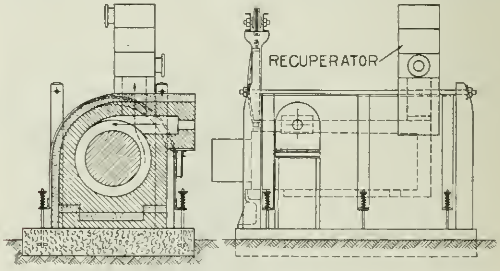


Fig. 204.

added difficulty that each ingot must be handled twice as often as before. The upshot is that the preheating furnace is used rather seldom.

If a preheating furnace is attached to a high temperature forge furnace, the connecting flues must be made quite large, (roughly speaking, with not more than 20 feet per second), to prevent excessive infiltration of cold air into the preheating section.

Since several furnaces must be used in any event, it appears logical to carry the subdivision still further and to use only one, or not more than two ingots per furnace. With individual furnaces the radiation losses will be greater, but the system affords a much greater flexibility on account of an almost continuous working. One or two furnaces are cooling down, others are heating; a medium warm furnace can have the openings around the ingots closed up; another furnace may be repaired, and so on. The principal drawback to the one ingot per furnace system lies in the large floor space requirements. The fuel consumption of this furnace may be kept within reasonable limits by the use of the "Rota-flame" principle, see Fig. 204. The flame is projected into the furnace at high velocity. The space between the furnace and the ingots must be reasonably small so that the flame will keep on whirling until it reaches the flue. The heat is greatest, where the ingot looses heat through the door opening, (see Part V), and yet the direction of the flame is such as to not throw any flame out at the door. During a large part of the heating period, the flue gases leave the furnace with a comparatively low temperature. The cylindrical shape of the furnace reduces the radiating surface as much as it can be reduced with individual furnaces. If further fuel reduction is desired, a cast iron recuperator can be put on top of the flue for preheating the combustion air. Furthermore, the furnace can be insulated with Sil-O-Cel or Nonpareil. In that case the bricks which are struck by the hottest flame must be of the very highest quality, such as suprafrax, carborundum or magnesite. A drawback of the roto-flame principle is that there should be different sizes of furnaces for the different size ingots.

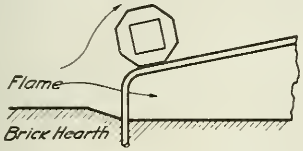


Fig. 205.

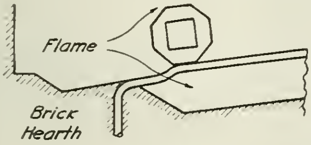


Fig. 206.

Since the regenerative principle has been a fuel saver in many heating and melting operations, it has also been applied to heating furnaces for heavy ingots. Its success is impaired by the fact that, before a new charge can be put into the furnace, the latter, including the checkers, must be cooled down. The greater the mass of brick in the furnace and the checkers, the greater is the loss due to cooling between heats. In a single-ingot forge furnace of good repute, it was found by test that the heat which was put into the brickwork and which was dissipated between ingots amounted to over 30 per cent of the total heat liberated by the fuel and to about double the heat stored up in the heated steel. Arrangements might be made by means of which the heat of the checkers can be retained, while the furnace proper is being cooled off, but any such arrangements would introduce additional complications. A better plan would be to use very thin, long, checker tile, not more than 1¼ inch thick, solid chimney construction, for the purpose of minimizing the useless heat storage.

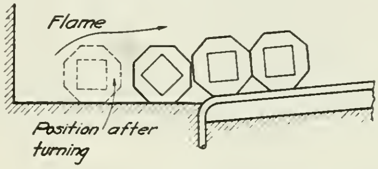


Fig. 207.

In this connection it should be noted that the forge furnace for heavy ingots is quite different from the "soaking pit" or more properly speaking, the pit furnace. The latter is charged with hot ingots fresh from the ingot stripper, and works at all times at high temperatures, while the forge furnace must be pulled down to 1400 degrees F. between heats.

Everything considered, it appears that the individual ingot furnace with the whirling flame and with recuperation of some of the waste heat is the best for the all-around heating of heavy ingots, particularly if it is made of thin walls of the highest grade firebrick, covered with insulating material.

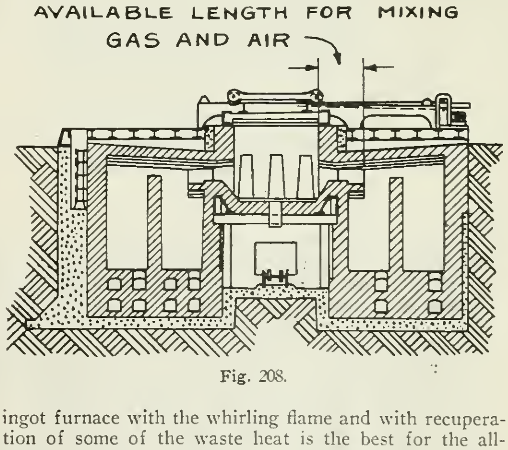


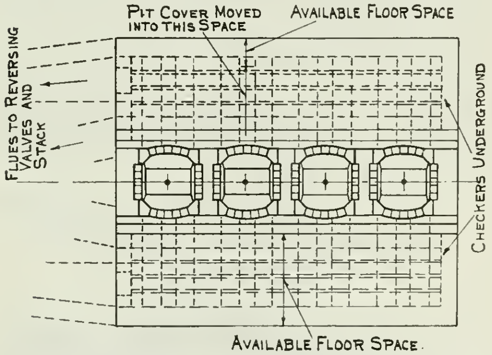
Fig. 208.

Extremely heavy ingots, such as used for naval guns, are heated on a car, because of difficulties in handling.

Conditions are quite different, as soon as ingots of uniform size are to be heated, such as occur in large orders of marine shafting railroad axles, wheel tires, etc. In a plant doing repetition work of this sort, a continuous furnace, or a group of continuous furnaces is a good investment, provided that the work is properly engineered.

Ingots up to 23 inches diameter (or rather short side of octagon) have been successfully pushed over pipe skids and have been heated to forging heats in continuous furnaces. The difficult part of these furnaces lies in the construction of the forehearth. On account of the large weight of the ingots, wide skid rails are used (2½ inch pipe or larger) and wide black spots are produced. From part XXIV it is quite clear that the vanishing of large black spots takes about a quarter of an hour. The ingots must, therefore, stay on the fore hearth for at least that length of time, after having been turned over. It goes without saying that ingots of that size and weight cannot be pushed across a brick hearth, because of the damage which they would do to a soft, slaggy hearth, and because they could never be heated with any degree of uniformity on a ventilated or water cooled hearth, while resting on the latter with the black spots of the ingots down.

The whole difficulty of forehearth design lies in the turning over of the ingot. If, as indicated in Fig. 205, the ingot is allowed to drop so that it will bring the cold spots up, the hearth will be seriously damaged, by having four or five tons land on it at regular intervals after a fall of a foot or more. A rolling action may be obtained by arranging the skid pipes as indicated in Fig. 206. A sliding section is provided for the purpose of allowing the flame to pass under the ingots. A very positive turning action can be obtained by letting the manipulator reach into furnace and turn the ingot, see Fig. 207. In that case the dropping and sliding are avoided, but there is no chance for the flame to pass freely to the under side of the ingots. Besides, two furnaces must be used or else a very long forehearth must be provided. In the cast of two furnaces, the manipulator reaches into one furnace to turn an ingot over, and then reaches into the other furnace for the purpose of pulling out an ingot. In the case of one furnace, an ingot, (call it No. 1), must be moved out of the road; another ingot, (call it No. 2), must be turned, and then the first ingot, (No. 1), must be picked up and taken out by the manipulator. This procedure causes loss of time, undesirable heating up of the end of the manipular and great heat losses from the furnace on account of a very large door's being open for a considerable length of time.


Pit Cover Moved into this Space
Available Floor Space
Flues to Reversing Valves and Stack
Checkers Underground
Available Floor Space

Four Hole Pit Furnace. Plan View
Pit Covers Not Shown.

Fig. 209.

"Vertical heating," as it is called, appears very attractive and is much used in soaking pits of steel works. On the other hand it is found very seldom in forge plants. The reasons for this difference are quite obvious. Odd shaped, partly finished forgings cannot be reheated in a vertical position, and various sizes of ingot cause difficulty in handling. Short ingots for small forgings, are almost lost in the pit and are hard to pick up, while long ingots stick up through the top and require the making of special pit covers. As a rule, pit furnaces are built without sufficient room for flame development between the burner and the ingot, see Fig. 208. With hot charged ingots, very little flame is needed, and the scaling is not excessive, but with a cold charge, there must, of necessity, be a greater fuel consumption in unit time, a longer flame, and more free oxygen at the place where the ingots stand. This fact means that pit furnaces for cold ingots should be designed with more room than the standard pit for steel works. However, that precaution is very seldom used.

Pit furnaces take up a comparatively small floor space, as may be judged from Fig. 209. On account of the underground construction it is generally believed that radiation losses are small. For long forging ingots that belief is rather imaginary, because it has been found necessary to ventilate the walls between the cells, in order to keep ingots leaning against a partition wall from pushing the wall into the next cell. The ventilating feature consists of structural steelwork between two brick walls. The walls are strengthened sufficiently by this design, but the supposed saving of radiation losses has largely disappeared.

It is thus seen that no one type of forge furnace for heavy ingots combines all of the advantages or gets rid of all of the disadvantages. No matter what we may do in excellence of design, there is always some feature with which fault may be found.

FIRST INGOT CAST AT NEW NAVAL ORDNANCE PLANT.

On February 2, 1921, the first armor plate ingot was cast at the United States Naval Ordnance Plant in South Charleston, W. Va.

This marked the formal opening of the Navy owned steel plant, which has been under consturction for the past two years.

The event was witnessed by Gordon Woodbury, Assistant Secretary of the Navy, Admiral C. B. McVay, Chief of the Bureau of Ordnance, Navy Department, Captain George R. Marvell, Inspector of Ordnance in Charge, and many invited guests. The work was supervised by William J. Priestley, Steel Superintendent.

In order to obtain steel for armor plate of greater resisting qualities, electric furnaces have been installed for refining and perfecting the steel as it comes from the open hearth furnaces.

WHEELING STEEL REBUILDING.

Freyn, Brassert & Co., Chicago, have been engaged as consulting engineers by the Wheeling Steel Corporation in the rebuilding and remodeling of No. 1 LaBelle furnace and of the Martins Ferry plant. At La Belle the improvements will consist of enlargement of the furnace for augmented capacity, together with relining of the hot blast stoves and installation of a gas cleaning system complete with other parts.

Discussion on "Electric Steel" Paper

Recent Paper Prepared by C. G. Carlisle on "Strength In Electric Steel," and Presented Before British Iron and Steel Institute Discussed.

By R. J. WEITLANER,
Electric Steel and Forge Company.

THE writer of this article would like to discuss a few points in connection with a paper presented by C. G. Carlisle before the British Iron and Steel Institute September, 1920, and reprinted in THE AMERICAN DROP FORGER, October, 1920.

All those familiar with the production of quality steel in the electric furnace will agree with the author that failures of electric steel were mostly due to lack of experience on the part of those directly responsible with the manufacture, this fact being especially the case during the rapid installation of electric furnaces during the war times and cannot be any inherent defects of the electric furnace process as developed so far.

It is however, very doubtful if any cases could be cited where steel was made in the United States by the clock method as so graphically described by the British metallurgist, the much talked of tonnage in this country notwithstanding.

The author discusses the removal of sulphur and phosphorus in the basic electric furnace by the well known equations but mentions a resulphurization of the bath, to the following equation:

$$\mathrm{CaSO4 + 4Fe = FeS + 3FeO + CaO}$$

*I do not think that calcium sulphate is a stable compound at such high temperatures as prevail in the electric furnace, but am rather inclined to ascribe this throwing back of sulphur into the bath to the reversible equation.

$$\mathrm{CaS + FeO = FeS + CaO}$$

This reaction is very likely to occur when a good deoxidizing slag is allowed to fall back due to lack of attention on the part of the melter the slag changing its appearance from a light to a dark color.

This falling back of a well deoxidizing slag is very often caused by the dropping of silica bricks into a deoxidizing slag, reducing its basicity and destroying its reducing capacity. This latter action may perhaps be explained by the equation:

$$\mathrm{2CaC_2 + 3SiO_2 + 3Fe = 2CaO + 3FeSi + CO}$$

resulting in an increase of silicon in the bath but at the same time weakening its reducing action, and through absorbing of FeO and MnO turning into a slag unfit for a proper finish.

Such a case is liable to occur in the final stages of a melt, when it becomes necessary to bring the bath to its proper tapping temperature.

Quick addition of lime and coke and simultaneous lowering of the temperature will in most cases undo the damage, but in cases where a large amount of slag has been allowed to accumulate the best remedy is to draw off the greater part of it.

I must also take exception to the statement in this paper that the size of the electric furnace is mainly the cause of a higher sulphur and phosphorus content in the final product.

It is true that the surface of the bath increases with the square of the circumscribed sphere whereas the volume of the bath increases with the cube of the radius of the sphere, on the other hand a deep bottom in any size furnace will influence the proportion of surface to volume in a way detrimental to the action of the slag upon the metal.

But the fact that sulphur and phosphorus may be somewhat higher in melts from larger size furnaces is also due to the fact that a larger proportion of slag to metal is used in smaller furnaces as compared to larger furnaces, and furthermore that the time for reaction between slag and steel is not proportional to the increase in tonnage between large and small furnaces.

Desulphurization can certainly be carried out to a very low percentage of sulphur even in large furnaces if a greater amount of time and care is taken for this stage of the operation and when slag materials, like lime, spar and coke of greatest purity are used.

The concentration of sulphur in steel and slag has a great deal to do with the reactions taking place between the two media. If impure lime or spar (the latter often contaminated with an unusually high constant in sulphides of lead and zinc) is used, the elimination of sulphur cannot be carried down to extremely low sulphur percentage.

The elimination of phosphorus should not present any greater difficulties than that of sulphur, provided again enough time be allowed for its absorption by the slag.

Here however, rephosphorization is liable to occur through an excessive cutting of the banks during the reducing period and through phosphorus contained in additions like ferro-manganese, etc.

Another possible explanation for the lower percentage of sulphur and phosphorus in steel made in a smaller furnace has been given in a correspondence published in "Iron Age," December 23, 1920, page 1686, explaining the advantages of bottom connected furnaces, resulting in a circulation of the bath, and giving a better contact between slag and metal.

Aside from all these comments on the subject of electric furnace practice, we must heartily agree with the author's conclusion that the final slag plays a more important role as to soundness of the finished product in the basic electric furnace than in any other metallurgical process.

A few minutes inattention may change a perfect deoxidizing slag into a thin cutting slag full of oxides and when tapped resulting in unsound material which cannot be offset by the addition of a killing agent.

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*Compare Hofmann, "General Metallurgy," 1913, pages 96 and 99, where we find the heat of decomposition for $CaSO_4$ to begin at 1250 degrees C.

The Logic of Roll Design

Describing Why Flanges Must Be Reduced in the Part of the Groove—Rolling Rails Diagonally—Demonstrations Covering the Principles of Roll Designs.

By W. H. MELANEY.

PART III.

IN the two former articles the simpler forms of roll design have been explained, together with the reason why the general forms shown are usually followed. In this article the writer will endeavor to show that in other sections, such as channels, beams, etc., in which deep flanges occur, and which can not be slabbed under any of the methods heretofore shown, that an entirely different principle is brought into play, to accomplish the same general result, namely, the slabbing down of the metal into a thin flange, wherever such flanges occur in the production of any desired section and also show why the flow of steel does not always follow the path the roll designer wants it to. And right here is where some of the so-called mystery in roll design comes in, because as previously stated, the flow of the steel will follow the path of least resistance and when it does not seem to do so you will find that the reasoning with which this seems to be at varience is faulty.

Rolling Rails Diagonally.

The rolling of a rail diagonally (See Fig. 6) brings into play a part of two slabbing actions. That used on rails as ordinarily rolled and the other one used on beam flanges. This latter action will be explained in detail under beams.

While the angle at which a rail may be entered into a groove, when rolled diagonally, is limited by the amount of taper in the flanges, the more it can be placed on the diagonal the greater the slabbing action, as under this condition it more nearly approaches the simplest slabbing position.

. In Fig. (6) the slabbing of the flange is done in the open part of groove, as described on some of the other sections and is taken care of without turning the rail upside down, as is done under the ordinary process.

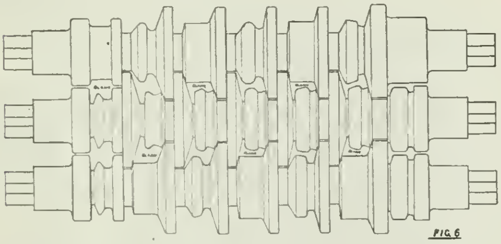


FIG. 6

The reduction of the flange takes place between the tongue of one roll and the collar of the other roll, on one side of the roll only, and the other flange is permitted to drop into the closed part of the groove with practically no side draft on the flange proper, but with sufficient reduction in the height of flanges to take care of elongation, and make the rail deliver straight. In this type of roll the flanges in the open part of groove are usually cut away at the end, permitting the flange to spread at will without danger of finning. Its height being controlled by the closed part of groove in the next pass.

As no slabbing action can take place in the closed part of groove, the flange on one side of rail is reduced in the open part of groove and the opposite flange is reduced at the next pass, also in the open part of next groove. This takes place all the way down to leader pass, where the rail is evened up for entrance into the finishing pass.

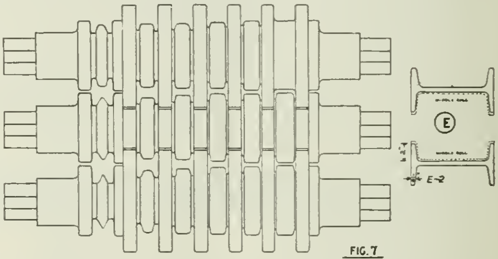


FIG. 7

You will note that the finishing pass is set parallel with the pitch line, and not on the diagonal, as in the other passes, as its use is to bring the rail to accurate dimensions all over.

In the present illustration (Fig. 6) the reduction from a bloom to a rail is shown in one set of rolls. It is obvious that two sets could be used if desired in order to shorten the rolls and facilitate production.

The most common use for this type of roll is where a large size rail is reduced to a finished rail of smaller section, as considerable upsetting action on height of rail can be obtained in each pass, and the rail gradually reduced in height to the size desired.

Channel Iron.

This section being similar to half a beam split lengthwise of section that is a web with flanges on each end, but extending on one side of the web only. This presents similar difficulties as are met with in rolling a beam, except that as the flanges are on one side of web only, they can be curved outward if desired, and a greater slabbing action obtained than is possible on a straight or perpendicular flange. Where deep flanges are required, this outward curve of the flange is used. Also on large sizes, as they can be rolled from a thinner slab and the same action obtained as in the butterfly angle.

The smaller sizes are usually rolled similar to a beam and the same principle used to produce the flanges as are used on a beam. This will be explained in detail under I Beams.

Rolling I Beams.

The rolling of an I beam presents a different condition than any of the sections described previously, as it has flanges both sides of the web and on both ends of the section, therefore, it is rolled with the flanges vertical (Fig. 7).

The ordinary slabbing effect, such as previously described, can not be obtained on this section, so an entirely different principle is used. Assuming, as stated, that the flow of the steel in rolling will follow the path of least resistance, then if a beam pass was designed with an equal amount of reduction on the sides of the flanges, on both sides of the beam, the uninitiated might see no good reason why the steel should not fill both sides of the groove equally, as the reduction on both sides would, under this condition, seem to be exactly the same. But such would not be the case.

The flanges on the open part of the groove would overfill and force the steel between the tongue of one roll, and the collar of the other roll, thus producing a fin, and the flanges in the closed part of groove would fail to fill up, leaving the flanges short in length. This results because the resistance to the flow of the steel is greater on one side of the bar than it is on the other, and is due to two reasons:

First, because one side of the beam is being rolled in the open part of groove and the other side of beam in the closed part of groove, and second, because the open part offers less resistance to the flow of the steel, because of the following conditions:

Place between the palms of your hands a lump of moist clay or putty, as shown in Fig. 8-H, press the hands tightly together and you will find it takes considerable pressure to squash the clay into a flat mass. But, if while applying this pressure you also give your hands a semi-rotary motion, as shown in Fig. 8-J, you will find that the clay will spread over a much greater surface and with less pressure than was required without this motion.

This is because you have produced a slabbing action, but by a different method than has been described heretofore. This is the type of slabbing action that is produced between the tongue of one roll and the collar of the other roll, in the open side of groove and is entirely absent on the other, or closed side of groove, and as a consequence, the steel will flow into the open side of groove as the path of least resistance, and away from the closed part of groove.

If you will refer to Fig. 8-G, showing an end section of the rolls, you will note that the tongue of one roll and the collar of the other roll are both revolving toward the vertical center line of rolls, but due to the difference in their diameters, are traveling at different speeds, producing a certain amount of sliding action between the two surfaces. This causes a spreading of the steel and at the same time forces the steel towards the vertical center line, crowding it in until this line is reached. Then the two surfaces start to receed from each other, immediately releasing the steel from pressure between the two surfaces, and permitting it to deliver without resistance. This has produced the same quashing action that took place between your hands when given the semi-rotary action (Fig. 8-J).

This action takes place on one side of the groove only, as all the surfaces on the closed side of groove move in unison, no slabbing action can take place and all parts of the flange on the closed side of the groove offers the same resistance to the flow of the steel into the flange groove, and if no other cause intervened, the steel would still flow into the open part of pass, as its path of least resistance.

But another element also intrudes itself to accentuate this action. Say the flanges were 2 inches high but only ¼ inch thick and tapered full length of flange. (See Fig. 7-E-2). Now suppose you wished to reduce the flange 1-16 inch in thickness. It is apparent that to force this flange into a tapered close flange groove, such as exists on the closed part of groove, you would have to reduce the flange 1-16 inch in thickness over the entire surface of its 2-inch height. While to upset or reduce the height of flange would only require a reduction over a section equal to its ¼-inch thickness (Fig. 7-E). Therefore, as there is no slabbing action in this close groove and every part of the flange is subjected to practically the same pressure, the steel flows in the direction of least resistance, which is to reduce the height of the flange rather than its thickness, because this part of the flange has the least area and the flange would come out of this groove shorter than it went in, because of the upsetting action on the flange.

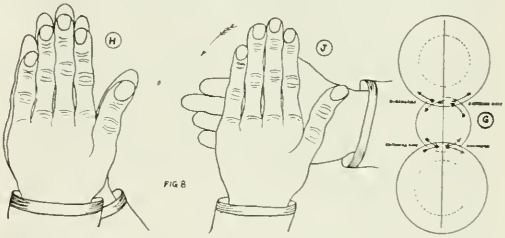


FIG 8

A flange will only drop into a close tapered groove to a depth sufficient to cause enough pressure to upset its cross section (Fig. E-2) and ride there. The extra metal being forced into the open side of groove and over filling it, so that the bar as delivered from this groove would have the flanges on open side overfilled, and the flanges on the closed side not filled up.

Therefore, the logical thing to do is to reduce the flanges in thickness on the open part of groove only. In other words, between the tongue of one roll and the collar of the other roll. This reduces the flanges on one side of beam at a time, the flanges of other side dropping into the close grooves (Fig. 7-E), then on next pass this same action takes place on the other flanges and without turning the beam over as on a three-high set of rolls, the tongue roll is on top of the bar when entered on the bottom pass and on bottom of the bar when entered on top pass.

This means that the flanges on one side of beam will be thicker than those on the other side after every other pass, except the finishing pass. The next to finishing pass being one where the flanges are equal.

(Continued on page 238)

On The Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesmann Oblique Rolling Process.

By DR. ING. KARL GRUBER IN RHEYDT.

PART I.

THE brothers Mannesmann of Remscheid have the distinction of having been the first to find out that it is possible to hollow roll round bar between rolls that are arranged in a warped plane. This invention caused a tremendous stir in the whole engineering world in 1888-90, more especially so as the inventors were expecting a far more extensive utilization of the process at the time than what was actually realized later on. Oblique rolling mills had been known for about 10 years, but they were used for straightening and polishing of round bars and tubes only.

The first patent for making tubes by means of oblique rolling mills was granted in Germany in 1886 under No. 24,617, through the instrumentality of the brothers Mannesmann, to Dr. F. Koegel and, based on the invention, rolling mills were erected in Remscheid, in Bons, near Saarbruecken, as well as in Bohemia, in Komotan, later on in Landore, in Wales, and also in Rath, near Duesseldorf. The process, however, experienced may difficulties right from the beginning and, although monetary assistance came from all sides, it was unable to attain the success hoped for. The cause of the failures was mainly due to the attempts to produce finished tubes on the oblique rolling mills, a method which, later on, has been completely abandoned.

The trouble was not so much with the designs, which were perfectly developed, but with the material which could not be made or produced of sufficient homogenousness as required for the oblique rolling process, viz.: in a state in which the molecules showed adequate cohesive properties. Material showing cracks and pipe even today causes a lot of trouble, with perfect equipment.

The oblique rolling mill is now only used as cogging, or blooming mill, for producing, from round bar, hollow shells of from 20 to 30 mm thickness of wall and such weight as to produce tubes of from 8 to 10 and even 12 m in length. For making finished tubes of from 2½ to 10 or 12 mm thickness of wall, finishing rolls are used, which are another invention of the brothers Mannesmann and go by the name of pilgrims-step rolling mills (Perrins process); they were patented in Germany for the first time under No. 58,762.

The oblique rolling mill, with face plates, has been developed further by the German-Swiss R. C. Steifel, who lives in the States, for the Engineering Company, Ellwood City, Pa., on similar lines to those laid down by the first Mannesmann patent specification (No. 34,617).

In the following the basic principle of the oblique rolling process is to be investigated somewhat more closely, following in doing this a paper read by Prof. Reuleaux before the Berlin district association on April 16, 1890.

Let us assume that there is a specimen A with a shaft supported by bearings and that a roll B, arranged obliquely in relation to the axis of the specimen, can be rotated while pressing against the latter The bearings of the specimen A permit rotary and lengthwise movement of the latter.

If now roll B is rotated, the rotary movement is transmitted to the specimen A, but at the same time a lateral movement of the specimen A takes place, the movements being as follows: For a peripheral speed of the roll v, the rotary movement of the specimen is $v \cos \beta$ and the speed of the lateral movement amounts to $v \sin \beta$ where β is the angle of intersection of the two shafts. The force by which rotation and thrust are caused is provided by the pressure between roll B and specimen A. Let us suppose further that on the other side of the specimen A another pressed-on roll is arranged the shaft of which also forms an angle β with the axis of the specimen; then it follows that a more reliable lateral and rotary movement of the specimen is secured.

If now the specimen A is arranged in the bearing C in such a way that it cannot be shifted in the direction of its axis, in the point of contact of roll B with the specimen A a tendency will develop which tries to force the molecules of the surface in the direction of the side thrust mentioned above. This action probably does not take any effect at first except in the shape of wear of the surface. Still it leads to the basic principle of the oblique rolling process.

Now describing the process in its essentials as it actually takes place. The specimen A is kept back by a taper on the rolls and its surface molecules are pushed forward by means of roll B, which grips the specimen A. This action is not confined to the surface but extends down into the hot interior of the specimen A, the effect being, as I shall explain more fully later on, that material is drawn from the interior and moves spiral shape to the surface, and in a forward direction. The former assumption, viz.: that a mandrel has to be provided holding back the core of the material if the proper formation of a hollow is to be assured, does not appear to hold good. This view seems to have been held by the inventors, and also by Prof. Reuleaux.

The hollow bloom is formed even without a mandrel being used and the mandrel of the rolling mill serves the purpose only to equalize the thickness of wall of the material and to smooth its interior, and it is essential only, in the main, for the finishing pass of the specimen A.

(Continued in April issue)

Reprinted from Stahl und Eisen.

The Basic Open Hearth Melting Shop Equipment and Practice

A General Review of the Mixer Plant and Practice—Melting Furnaces — Metallurgical Practice — Handling of Materials and Products—Layout of the Plant.

By GEORGE A. V. RUSSELL,
Assistant Plant Manager—Sheffield, England.

PART II.

THE author approaches this next section of his paper with much diffidence as he is far from competent to deal with this aspect of melting shop practice in a manner worthy of the way it should be treated, and when its magnitude and interest are taken into consideration it will be readily understood that the necessary limitations of space in a paper such as this would preclude anything but a very perfunctory treatment of it if one attempted to range over the whole of this wide and most fascinating field. He thought therefore that instead of endeavoring to give a general resume it might be more profitable to consider in rather greater detail one or two aspects of current practice and has selected to touch upon some of the problems met with in accelerating the rate of steel production when working wholly or partially liquid metal charges in the basic open hearth furnace and then to say something on the processes which have been developed to get over, with varying degrees of success, it is true, the difficulties encountered.

To render useful the large quantity of sensible heat stored in molten pig iron from the blast furnace in the subsequent refining process was a problem which invited solution in all works combining blast furnaces and open hearth furnaces on the one site on account of the great technical advantage which such a practice appeared to afford, and the experiment of employing molten pig iron in the steel furnace was tried in many instances however without yielding the results anticipated. The rate of production was but little higher than with cold charges in the same furnaces and the wear and tear on the furnace structure exceedingly heavy, and again, in taking blast furnace metal directly to the steel furnace, without any mixer or storage vessel between the two, frequent delays arose in transport and in the tapping of the blast furnace, which considerably upset the smooth working of the melting shop by causing furnaces to wait unduly for their charges and finally the virtually inevitable variation from cast to cast and from furnace to furnace in the composition of the pig metal supplied largely accentuated the difficulties met with in those early days.

In spite of these serious obstacles it was clearly appreciated that such a development must be along the path of true progress and hence with the great expansion of the open hearth process which took place towards the beginning of the present century, the problem was attacked with greater determination than had hitherto been brought to bear upon it, with a result that many modifications in working were proposed, based on more or less sound principles. At the same time the knowledge of the physico-chemical laws governing the course of the reactions in the open hearth process, such as the difference in energy change taking place in the reactions between iron ore and the metalloids in the pig iron, and the influence of temperature and concentration upon the velocity of such reaction was steadily increasing, thus placing at the disposal of the practical metallurgist the key to the solution of many problems with which he had been confronted and opening out to him many new vistas of profitable thought. Concurrently with the progress on the metallurgical side, important improvements in the mechanical appliances available were introduced, which rendered possible methods of working previously impracticable.

The introduction of the mixer into works practice at once assured adequate supplies of pig metal being available for the steel furnaces exactly when required and in a degree dependent upon its relative capacity, reduced the magnitude of the variations in composition of the metal.

The chief cause of the difficulties encountered in working liquid metal charges in the furnace and of the relatively poor output obtained was the excessive slag formation per ton of steel. Slag, although an inevitable product in most refining operations, and an essential one in the open hearth steel processes, being as it is the vehicle for the active reagents employed in the elimination of the metalloids of the charge as well as retaining in solution the oxidation products of thsee elements other than gases, is nevertheless, when in excess a great hindrance to rapid working; as not only is it a poor conductor of heat, in this way acting as an insulator between the bath and the furnace gases, but has itself a considerably higher specific heat than steel at a given temperature, thus absorbing much heat in raising it to the tapping temperature, which might otherwise have been more usefully expended in increasing the velocity of the refining reactions, hence it follows that the slag should be present in as small an amount as compatible with the performance of its chemical functions at any time during the course of the process. Mr. Bagley has stated in a valuable paper, to which reference has already been made, that taking any particular process if the slag make can be decreased one per cent, the steel make will be increased approximately 2.5 per cent, and in comparing similar practices together these figures will be found pretty near the mark.

It will be noted that the various modifications that have been put into practice for accelerating output are dependent for their success in this direction, upon the decreased slag make resulting per ton of product, or that the quantity of slag in contact with the metal at any given time is greatly reduced. In some of these processes the pig iron is diluted by either molten low carbon and highly oxidized metal, as in the well known Talbot continuous process, or by scrap steel, as is now practiced to a varying extent in many plants. In others the slag volume is diminished during the progress of the heat by pouring off a certain amount or all of it at given intervals. This may be done either when the slag has ceased to be active, i. e., when refining in stages is employed, as in the Bertrand Thiel process and its more recent modifications the Hoesch and the Dortmunder Union processes, or when it is still chemically active and far from spent, as in the Monell process. Frequently a combination of both these methods is employed, the pig being diluted down with scrap, and during the process of the heat a certain amount of slag is run off. Again, sometimes, the charge is partially refined by the pneumatic process, the slag arising therefrom separated from the metal and the latter either finished in a comparatively small fixed furnace, with or without scrap, as in the old Witkowitz process, or poured into a large bath of low carbon metal, as in current duplex practice in the States.

Having stated in general terms the principle upon which modern open hearth liquid metal processes depend it will now be well to consider more closely representative examples from practice embodying each of these three main methods available for applying this principle and the following will be taken for this purpose:

1. The liquid metal and scrap process conducted in fixed furnaces.
2. The Hoesh modification of the Bertrand Thiel process.
3. The American duplex process (combination of acid Bessemer converter and basic open hearth furnace).

Liquid Pig and Scrap Process in Fixed Furnaces.

The usual method of conducting this process is well known, so it will be unnecessary to dwell upon it at length. Briefly, some ore and lime are charged into the furnace together with the scrap, the pig metal is then poured in and the charge worked down in the usual manner with oxide and lime until the phosphorus and carbon have been eliminated to the desired extent. The slag should be as nearly as possible spent at tapping so that its action on the metal has practically ceased, that is to say the content of its active reagent, oxide of iron, should have fallen to something between 13 to 16 per cent. However, if the slag is allowed to get lower in Fe O than about 13 per cent and the ferro manganese is added in the bath there is a tendency for the carbon thus introduced to reduce phosphorus from the slag to the metal, a reaction that can only be tolerated to a very limited degree. Hence, in making a high class product it is customary to work the FeO content of the slag down to between the limits indicated and then add the greater portion of the deoxidizers in the bath and the balance of them in the ladle. In making high carbon heats it is generally the practice to work the charge down "dead soft" and then recarburize in the ladle with anthracite or cake dust. Catching the carbon on the "way down" makes greater demands upon the skill of the melter, as it is essential that the phosphorus be eliminated sufficiently before the carbon is at the required point which can only be achieved by correct bath conditions during the early stages of the heat. However, if these are obtained this method of working saves time and if the slag has not been over dosed with oxide before tapping the resulting steel will be of excellent quality.

In Tables 8 and 9 will be found particulars of four representative charges worked by this process. Table 8 contains data on the materials used in the charge, product obtained and times taken, while Table 9 gives the chemical histories of the metal and slag during the progress of the heats. It is regretted that the chemical data for the British charges is so meager, but this is accounted for by the fact that these examples were taken at random from a large number of observations on the working of the basic process under ordinary every day conditions, with a view to getting an idea of the results achieved in regular commercial practice, so that only the usual bath samples were taken as required by the sample passer.

Table 8—Typical Liquid Pig and Scrap Charges.

No. of Charge		A	B	C	D
Works Source		Julienhutte Petersen 5	Author's Notes	Author's Notes	Author's Notes
Materials charged					
Mixer metal	kg	32,100	27,430	57,915	66,000
Iron and steel scrap	kg	8,170	18,290	20.320	15,540
Limestone	kg	.....	4,570	7,112	4,065
Lime	kg	1,000	....	....	3,050
Oxide (ore)	kg	7,200	6,100	10,160	12,192
Additions during working of charge					
Pig iron	kg	.....	....	4,065	1,525
Lime	kg	1,860	7,120	9,650	12,700
Oxide (ore)	kg	765	1,525	2,030	6,600
Oxide (Roll. mill scale)	kg	.....	760	760	1,525
Finishing additions to bath					
Ferro manganese.....	kg	165	355	....	662
Finishing additions to ladle					
Ferro manganese	kg	.....	....	547	....
Production					
Good ingots	kg	39,490	45,265	85,145	88,095
Scrap	kg	970	....	....	....
Yield of good ingots..	pc	98.1	99.2	103.1	105.7
Yield of ingots, scrap	pc	100.5	....	....	....
Times					
Charging	hm	1.10	2.35	3.00	2.40
Commencement of charging to tapping	hm	5.50	12.15	14.30	19.05
Rate of steel prod'n.	kg/min	115.3	61.6	98.0	79.0
Composition of Pit Sample					
Carbon	pc	0.113	0.093	0.086	0.127
Silicon	pc	trace	0.019	0.009	trace
Sulphur	pc	0.03	0.038	0.03	0.041
Phosphorus	pc	0.034	0.028	0.028	0.032
Manganese	pc	0.45	0.43	0.47	0.45

The data on the Julienhutte charge, is however, much more complete, and as this charge is typical of good practice, the author has used it to illustrate the general course of the reactions in the basic process. To this end Fig. 11 has been prepared in order that numerous figures arrived at by observation and calculation be rendered more apparent than would be possible by tabulation.

The upper diagram, shows in the usual manner, the variation in the composition of the bath during the progress of the heat. Above these curves a temperature curve will be noted. It should be understood however that this is only approximate, but nevertheless is of great utility in bringing out more prominently the fundamental relation between temperature and the velcoity of the different reactions. It will be observed that during the early stages of the heat when the temperature is low the exothermic silicon phosphorus and manganese reactions have preference, while the carbon is attacked much more slowly. The small depressions in the temperature curve correspond to the ore and lime additions, as Dr. McCance in his brilliant work on the acid open hearth process, has found that a pronounced lowering of bath temperature, due to absorpton of heat, takes place when these additions are made.

The lower diagram, although a work of some labor, is well worth the trouble it entails, as it assists considerably in obtaining a more precise notion of the actual distribution of the oxygen used in eliminating the metalloids at any period of the "chargdure."

The author will not pause to give an explanation of the method of calculation employed in arriving at a diagram of this nature, as those interested will find full particulars elsewhere,*14 but will pass on to consider some of its salient features. The ordinates are weight of oxygen expressed as a molicular percentage of the weight of the charge. The line a—a gives amount of oxygen at the disposal of the bath at any time. The area enclosed between the lines bc—ca and bd—d, shown crosshatched, gives the amount of oxygen in the form of FeO dissolved in the slag. As a basic slag ceases to be active when its iron content is lowered to 10 per cent, the amounts of oxygen which were in combination with iron which exceeded 10 per cent of the slag weight were ascertained and deducted from the total oxygen in the slag to give the amount of active oxygen available for doing work at any time. This is indicated by the double crosshatched area. The line bd—d shows the amount of oxygen expended in removing all the metalloids, and the line bde—e that consumed in eliminating all the silicon, phosphorus and manganese. Hence the area lying between these shows the amount required for the oxidation of the carbon.

Table 9—Chemical Histories of Charges Given in Table 8.

Charge	Time from start h.m.	Metal C. pc	Si. pc	S. pc	P. pc	Mn. pc	Slag FeO pc	Mn pc	Al_2O_3 pc	CaO pc	MgO pc	P_2O_5 pc	S pc	SiO_2 pc	Remarks
A	...	3.610	1.21	.05	.41	2.10	....	...	...	....	...	...	...	....	Mixer metal
	1.50	...	...	...	...	...	41.3	10.56	2.40	14.86	7.14	3.50	.061	20.20	
	1.20	...	...	...	...	...	42.04	10.15	1.40	15.40	7.05	3.85	.066	20.05	
	3.15	.73	trace	.037	.066	.06	25.38	9.11	3.40	23.89	9.03	4.03	.068	24.6	
	4.05	.635	trace	.029	.048	.10	16.23	9.19	4.50	32.06	8.41	3.50	.057	25.7	370 kg lime.
	4.20	.497	trace	.030	.052	.13	13.65	8.70	4.08	34.47	7.80	3.57	.075	26.98	490 kg lime. 255 kg ore.
	4.35	.386	trace	.037	.042	.15	13.51	7.67	3.74	36.89	7.87	3.57	.068	26.70	560 kg lime. 340 kg ore.
	4.50	.272	trace	.038	.032	.14	14.73	7.50	5.06	35.98	7.80	3.71	.066	24.8	210 kg lime.
	5.00	.211	trace	.035	.036	.17	14.19	6.87	4.08	39.08	7.51	3.37	.068	23.7	170 kg lime.
	5.15	.142	trace	.03	.035	.17	13.37	7.36	3.95	39.97	7.76	3.50	.078	23.9	110 kg lime.
	5.25	.104	trace	027	.032	.19	13.24	6.87	4.22	39.69	7.99	3.37	.075	23.9	120 kg lime.
	5.40	.088	trace	.03	.029	.19	13.37	6.25	4.28	42.97	7.44	3.21	.068	21.86	165 kg ferro manganese.
	5.50	.113	trace	.03	.034	.45	12.69	7.60	4.26	43.89	6.90	3.21	.068	20.85	Charge tapped.
B	...	*	.89	.056	1.26	1.45	....	...	...	....	...	...	...	....	Mixer metal
	6.45	12	*	*	.45	*	....	...	...	....	...	..	...	....	
	9.00	...	...	...	...	...	10.4	*	*	*	*	*	*	*	
	9.48	...	...	...	...	...	13.0	*	*	*	*	*	*	*	
	10.35	.10	*	.051	.06	*	....	...	...	....	...	...	...	....	
	11.00	.10	*	.045	.045	.18	....	...	...	....	...	...	...	....	
	12.00	...	...	...	...	...	...	...	...	....	...	...	...	....	355 kg ferro manganese.
	12.15	...	...	...	...	...	...	...	...	....	...	...	...	....	Charge tapped.
C	...	*	.93	.084	1.31	1.74	....	...	...	....	...	...	...	....	Mixer metal.
	8.30	.15	*	.078	.35	*	...	...	...	....	...	...	...	....	
	9.05	.10	*	.083	.18	*	...	...	...	....	...	...	...	....	
	10.45	.12	*	.080	.10	...	9.75	...	*	*	*	*	*	*	
	11.05	...	...	...	...	...	11.05	*	*	*	*	*	*	*	
	11.30	.10	*	.056	.045	*	...	...	...	....	...	...	...	....	
	12.15	.11	*	.056	.040	*	15.6	...	*	*	*	*	*	*	
	12.55	.10	*	.042	.040	*	...	...	...	....	...	...	...	....	
	13.30	.10	*	.039	.030	.26	...	...	...	....	...	...	...	....	
	14.30	...	...	...	...	...	...	...	...	....	...	...	...	....	Charge tapped.
D	...	*	1.07	.079	1.28	1.56	...	...							Mixer metal
	9.30	1.00	*	*	*	*	...	...	...	....	...	...	...	....	
	14.45	.14	*	.074	*	*	14.3	*	*	*	*	*	*	*	
	16.15	...	...	...	...	...	15.6	*	*	*	*	*	*	*	
	17.05	.10	*	.06	.045	...	18.2	*	*	*	*	*	*	*	
	18.10	.10	*	.05	.03	.16	...	...	...	....	...	...	...	....	
	18.50	...	...	...	...	...	...	...	...	....	...	...	...	....	662 kg ferro manganese.
	19.05	...	...	...	...	...	...	...	...	....	...	...	...	....	Charge tapped.

In this particular charge, as should be the case under proper conditions, the oxygen requirements of the silicon, phosphorus and manganese were soon satisfied, while the carbon, taking only a small portion at first, rapidly became the sole consumer. It will be noticed that for the last 100 minutes the slag was practically inactive and although three small ore additions were made, it is apparent that the carbon must have reduced the ore almost immediately. It was dissolved in the slag so that the FeO content of the latter did not materially rise. This action was no doubt facilitated by the relatively high bath temperature then existing.

The Hoesch Process.

The essential difference between the Hoesch Process and the original Bertrand Thiel is that in the former the charge after tapping out is returned to the same furnace for finishing, whilst in the latter it is transferred to another furnace. Metallurgically they are exactly the same. The method of working is as follows: The pig metal is poured into the furnace on lime and oxide previously charged and the temperature is kept down. This, coupled with the very basic oxidizing slag formed insures a rapid removal of the silicon, phosphorus, and manganese, the carbon being eliminated to a much smaller extent. When the slag has become spent the charge is tapped out and the highly phosphoric slag separated. In the meantime the scrap is charged together with further quantities of lime and oxide. The metal is now returned to the furnace and the temperature is increased as quickly as possible. The carbon reaction soon sets in and feeds of lime and scale are given as necessary until the bath samples are satisfactory, when the finishers are added and the charge tapped.

Large outputs of soft steel have been obtained by this process at the Hoesch Works, three heats per day being the regular production of the 100 tons fixed furnaces there installed.†15. The liquid iron taken from a 1,000 tons inactive mixer is, however, of excellent quality and no doubt in some measure contributes to these good results. The yield obtained is high, about 104 per cent, and the value of the very phosphoric primary slag in the basic slag in the basic slag market is considerable.

Table 10—Data on Charge "E" Hoesch Process.

Materials charged into furnace for first stage.

Mixer metal	23,280 kg
Lime	1,880 kg
Oxide (Swedish ore)	3,440 kg
Oxide (Rolling mill scale)	770 kg

Materials charged into furnace for second stage.

Iron and steel scrap	5,412 kg
Lime	1,290 kg
Oxide (Spathic ore)	2,182 kg

Feeds during second stage—Lime 366 kg. Rolling mill scale 105 kg.
Times—Commencement of charging to end of first stage, 2.30.

Finishing addition to bath. Ferro manganese 200 kg
End of first stage to end of second stage, 2.45.

Chemical History of Metal and Slag.

Time from	Metal					Slag									
start	C.	Si.	S.	P.	Mn.	FeO	MnO	Al_2O_3	CaO	MgO	P_2O_5	S	SiO_2	Remarks
m	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	
	3.28	.032	.132	1.86	.96	....	....	...	....	...	...	...	....	Mixer metal.
60	2.47	trace	.102	.59	.17	....	....	...	....	...	...	...	....	
62	1.90	trace	.098	.47	.22	10.25	5.03	1.36	41.56	4.32	22.85	.069	12.20	
65	1.65	trace	.098	.37	.22	7.06	4.96	1.38	45.48	4.00	22.36	.124	11.80	
150	1.46	trace	.082	.26	.34	4.67	3.93	1.60	48.86	4.00	22.13	.138	11.40	Furnace tapped.
180	...	...	...	...	..	....	....	...	....	...	...	...	....	Metal returned to Fur.
230	.38	trace	.100	.090	.29	19.64	13.49	3.17	33.64	6.92	6.25	.110	14.20	
250	.205	trace	.089	.050	.23	15.78	12.08	3.00	35.78	6.70	6.70	.165	15.40	105 kg roll. mill scale.
270	.090	trace	.090	.045	.26	15.83	8.88	2.32	43.88	6.00	5.50	.289	13.20	
285	.075	trace	0.80	.035	.26	14.13	10.19	2.21	43.79	6.10	5.57	.206	14.20	160 kg lime at 295 m. 206 kg CaO.
305	.058	trace	.078	.030	.27	16.23	8.32	2.20	45.30	5.90	5.55	.275	14.00	
310	.045	trace	.077	.030	.25	17.20	7.67	2.20	46.19	6.12	5.15	.316	13.10	200 kg ferro manganese
315	.080	trace	.067	.040	.47	17.03	10.25	1.90	46.28	5.92	5.00	.344	12.40	Furnace tapped.

Production—Good ingots 29,990 kg., scrap (pit) 360 kg.
Yield—Good ingots, = 104.3 per cent. Ingots and scrap = 105.6 per cent.

Rate of steel production = 96.3 kg. per minute.

The American Duplex Process.

Perhaps one of the most striking features of American steelworks practice during the last five years or so has been the rapid growth of the duplex process. This is all the more remarkable when we remember that the only European works employing this process on a large scale, until quite recently, were driven to discard it on account of its high cost of production.‡13. The reasons for the success of this despised tool of the old world in America are partly economic and partly technical. The huge domestic market stretching out before the very doors of American manufacturers puts a somewhat different aspect on many production problems which works on both continents have to face. In the States output is vital and technical efficiency is often of quite secondary importance especially during periods of good trade, hence the poor yield inevitable with the duplex process, and the considerable heat losses engendered by the several transferences of the metal between the different units of the plant becomes insignificant when compared to the enormous output obtainable from a combined plant. At the same time it should be pointed out that very great elasticity in operation is possible with a well laid out duplex plant, as anything from straight Bessemer to straight openhearth working, with any desired combination of the two becomes feasible, so that the plant may be run either for maximum efficiency or for maximum output, according as the market conditions warrant. Success in duplex working is vitally dependent upon the layout of the plant as with the number of transferences of metal which are necessary, and the great rapidity of working it becomes essential that the sequence of operation be absolutely unobstructed. Again with the hard driving which is such a characteristic feature of blast furnace practice in the States it has always been difficult to obtain pig metal low enough in silicon to treat profitably in the open-hearth furnace unless diluted with a considerable percentage of scrap. Scrap, beyond that produced within the works, has been increasingly difficult to obtain in sufficient quantities of late years, especially in the great centers of steel industry. The duplex process provides a means of solving this problem. In the words of Mr. T. W. Robinson, vice president of the Illinois Steel Company, "Steel scrap or its equivalent is an economic necessity for the straight open-hearth process, but the underlying cause of the growth of the duplex process is its independence of a steel scrap supply."§.

In the American duplex process the acid Bessemer converter is used for desiliconizing and decarbonizing and the basic open-hearth furnace for dephosphorizing. By this means instead of carrying out a complex series of reactions in one furnace, which, while it may be capable of performing some of the reactions well, it cannot do so for all employs, the acid converter for eliminating silicon and carbon, both of which functions it is well suited for, and finishes the blown metal in the basic open-hearth furnace. The latter is thus fed with an iron containing no silicon and a little carbon and it is called on only to eliminate the phosphorus and the remainder of the carbon for which purpose it is well adapted.

To dwell at length upon the acid Bessemer stage of the duplex process would be outside the scope of this paper. Suffice it to say that the converters are

Table 11—Particulars of Equipment at Representative American Duplex Steel Plants.

Location	South Bethlehem	Lackawanna			South Chicago		Sparrows Point		
Mixers									
Number	2	1	1	2	1	300	1		1
Individual capacity tons	400	250	300	1300	1300	300	1300		250
Converters									
Number	2		4	3		2			4
Individual capacity tons	20		12	25		25			30
Fixed open hearth furnaces									
Number	10		8	..		..			..
Individual capacity tons	60		100	..		..			..
Tilting open hearth furnaces									
Number	..		2	3		3			4
Individual capacity tons	..		200	200		250			200
Ladle cranes in mixer building									
Number	1		1	1		1			1
Individual capacity tons	60		100	75		100			100
Ladle cranes in melting shop charging bay									
Number						3			2
Individual capacity tons				100		100			100
Ladle cranes in melting shop casting bay									
Number						2	1	2	2*
Individual capacity tons				175		175	100	175	40
Method of transporting metal between mixers and converters	E.O.T. Crane		Electric Haulage	Electric Haulage			E.O.T. Crane		
Method of transporting blown metal to open hearth furnaces	Loco ladle		Loco ladle	Loco ladle			E.O.T. Crane E.O.T. Crane		

*These cranes are for general "pit side" duties.

usually of large capacity—up to 30 tons in some instances—but otherwise do not present any features different from those employed in current straight Besemer practice. In operation, these large vessels, as a result of their lower radiation losses, have a marked tendency to blow "hot" with consequent high residual silicon content in the metal after decarbonization, which can only be got rid of at the expense of considerable oxidation of iron, thus diminishing the yield.

In so far as the open-hearth stage is concerned, the process as now carried out in large tilting furnaces of 200 to 250 tons capacity is practically the Talbot continuous process using refined iron. It may be of interest to briefly describe the working of a charge in one of these large furnaces. After the previous heat of, say 100 tons, has been poured out, the greater portion of the slag being retained in the furnace, the side walls along the slag line are repaired. Lime and ore are charged, the flame turned on and a basic and highly-oxidizing slag soon formed. Orders are then given to the Besemer department for the number of vessels required for the heat and as blown the Bessemer metal, cleaned of its silicious slag, is poured into the open-hearth furnace. The last Bessemer charge, or "kicker" as it is termed, is but partially blown, having about 1 to 1.5 per cent of carbon in the metal. Immediately upon the introduction of the "kicker" into the molten and highly oxidized bath a vigorous boil takes place, the slag frothing up and pouring out of the notches in the door sill plates. The violent ebullition of the bath assists much in bringnig the slag into intimate contact with the metal and the oxidization of the phosphorus is rapidily accomplished, if the temperature is not too high, and much of it passes out of the furnace in the slag. When the boil has subsided a metal sample is taken and the bath worked down accordingly. If the carbon is still high a further ore addition may be made, or if the phosphorus has not been eliminated far enough more lime may be necessary. When ready the heat is teemed and the recarburizer and ferro-manganese, or spiegel iron, are added in the ladle.

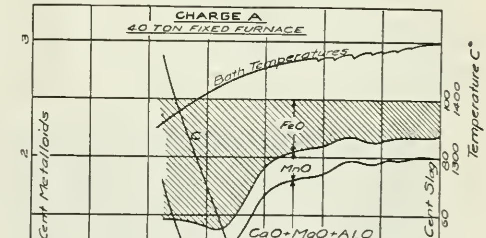


Fig. 1.

It is of great importance that the phosphorus be quickly attacked and removed to the desired extent before the carbon is all out. If much elimination of

(Continued on page 236)

Fitting by Forcing or Shrinking

In Machine Construction and Repairs These Methods of Holding Wheels on Shafts Have Proven More Satisfactory Than That of Using Keys.

By W. S. STANDIFORD.

IN the realm of machine construction and mill repairs, the importance of holding wheels on shafts by means of a forced fit instead of the usual method of securing the parts to be held together by means of a key, does not seem to be used to the extent that it should, considering the excellent results obtained with gear wheels, etc.; that are subjected to heavy vibration. Pinions held on the ends of shafts by a key will not stand jarring for any length of time, as sooner or later they cause trouble by getting loose and coming off their shafts. In cases where the shaking and pressure exerted upon a pinion is continuous, the latter will remain fast upon its support for a much longer length of time, than where the motion is intermittent and jerky as the heavy thrust and leverage soon forces out a key.

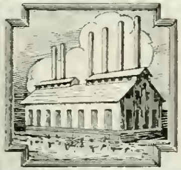
Two keys, put upon a quarter circle from each other will enable a pinion to remain longer on a shaft; but the writer has found out by experience, that where continuous running machinery is desired, and giving the least amount of trouble to a factory's repair forces, it is much better to force a gear wheel on a shaft by hydraulic pressure, no key being needed in this case, as a pinion or gear wheel pressed on in this manner will remain until it requires to be removed by reason of worn teeth; removal being easily and quickly effected by cutting a slot in the bottom of a tooth and forcing a wedge in slot and knocking the wheel off with a hammer. In making press or forced fits, the part that is to be driven, must of course, be larger in diameter than the hole which receives it, but the difference in regard to such press fits is not so great as some machinists think should be the case, as all that is needed is to have the grip between the two metals sufficiently tight so as to prevent the parts from coming off. Any heavier pressure used for work of this character puts a strain upon the metal around the hole that will cause a cast iron pinion to break suddenly while it is in action. The usual practice among machinists in doing work of this kind is to judge the proper amount of oversize allowance by the feel of a calipers; but this is a very uncertain method as errors are likely to be made in judging sizes.

The right way of taking such measurements is by means of an inside micrometer calipers used in the hole, and an outside micrometer calipers to find the shaft size. This puts all measurements upon an exact basis, the worker knowing at all times just what allowance has been given in thousandths of an inch, instead of a slipshod caliper feel, and its guesswork as to the proper amount of oversize required. A mechanic always gains by doing all work, whatever its character may be, as carefully as possible as bad habits once formed in doing work are hard to break and often lead to spoilt work. There is a limit to the sizes of articles made with forced or pressed fits, which is due to the fact that as the diameter of a shaft and hole in a pinion increases, more powerful hydraulic apparatus is required to press them together; so that a point is soon reached where it would not pay to keep an expensive and powerful machine around a shop for only occasional use.

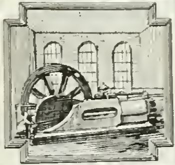
As a general rule, force fits are mostly made on such small objects as crank pins, car wheel axles, machine construction and other repair parts that require to be held securely. In judging the proper allowance for a press fit, several factors have to be taken into consideration, viz.: The thickness of metal surrounding the hole, kind and quality of material of which the parts are made, the size of the work and also smoothness and accuracy of bore and shaft that are to be fitted together. However, as a general rule, to make a press fit of the greatest possible strength, there should be a difference in the sizes of the parts to be fitted, of from two to three thousandths of an inch—for each inch of diameter of the article. The following formula will serve to give an idea of the pressure in tons required for making forced fits for different shaft diameters. The required pressure in tons will be the fit allowances in thousandths of an inch multiplied by the diameter of shaft in inches and also by the factor of 1½.

As an example. Suppose that a gear wheel is to be forced on a 5-inch shaft, the press fit allowance being .002 for each inch of diameter. 5 × .002 = .010 the latter being the allowance, and the pressure in tons will be 10 × 5 × 1½ = 75 tons. On smaller diameters of shafts where an extra heavy grip between the parts are desired, the larger figure of .003 inch can be used. Take the case of a 2-inch shaft; 2 × .003 = .006 the allowance, and the pressure in tons will be 6 × 2 × 1½ = 18 tons. It will be apparent to the readers of this magazine, that if the allowance figures given in both of the above cases, were adhered to for large sized shafts, that the necessary pressure would be very great and beyond the appliances found in most shops. To show this clearly, we will suppose that a 15 inch crank pin is to be fitted into its disk. Using an allowance of .002 inch × 15 inches = .030 multiplying 30 × 15 × 1½ = 675 tons pressure needed to do the work. Very few large factories possess the facilities for obtaining such heavy pressures, which make extra tight fits that are unnecessary, as all that is required is to make the parts hold together. In practice, for a shaft of 15 inches size, it will be found that an .010 inch press allowance will be sufficient, the tonnage necessary to force them together being much less. Some mechanics taper the parts to be fitted together thinking that tighter fits will result, this is bad practice, because the tendency of taper fitted parts to become loose under vibration is always present, and once it loosens, the entire fit frees itself, it taking very little axial movement to do so On the other hand, a taper fit does not abrade the surfaces of the parts pressed together, to the extent that a level fit does. In order to prevent abrasion in work of this kind, it is advisable to lubricate the surfaces with white lead mixed with a little lard oil, as it is best to keep the surfaces as smooth as possible, so as to allow for renewing gears, etc., on the same shaft when they are needed.

(Continued on page 236)



STEAM POWER DEPARTMENT



Installation of World's Largest Boilers

Description of Large Boilers Operating at the River Rouge Plant of the Ford Motor Company—Description of Superheaters and Powdered Coal Equipment.

By GEORGE T. LADD.

A DESCRIPTION of a plant or apparatus which has not been entirely completed must necessarily be limited to construction features. Much interest, however, has been shown in the construction details of the new power house at the River Rouge plant of the Ford Motor Company and it is with these details as applied to the boilers that this paper deals.

The power house itself consists of an east wing housing the turbo generators, a large bay at present constructed to receive eight boilers, four of which are now in place, and a west wing housing the turbo blowers for the blast furnaces. Steam will be generated at 240 lbs. pressure and superheated 200 degrees.

The boilers are of the five drum type, four steam and water drums and one top seam collector drum, with the tubing installed as shown in Fig. 1. The top steam drum is provided with two 10 inch nozzles, each of which is connected to one of the outside or saturated headers of the superheater, so that the course of the steam is from the relieving surfaces in the two main top drums, up through the steam connectors to the steam drum, thence down into the outside superheated headers, through the superheater elements and back to the central superheater header, one end of which constitutes the boiler outlet nozzle.

The floor space occupied by each unit is somewhat less than might be expected, being but 29 feet 0 inches by 31 feet 0 inches column centers. The furnace, while irregularly shaped, is approximately 23 feet 0 inches by 24 feet 0 inches inside by 55 feet 0 inches high above the ash pits. The combustion space allowed by this furnace, exclusive of the ash pits, is about 5 cubic feet per normal rated horsepower. The total height of the boiler from the ash pit floor to the top of the superheater piping is 82 feet 9⅞ inches.

Mounted over each boiler, and supported by the building framing, is a brick lined steel stack 11 feet 0 inches inside diameter, with the top reaching 327 feet above the ash floor level. Space is left between the top of the boiler and the base of the stack for the introduction of economizers, but these will not be installed until a future date.

The complete structure of the boiler, superheater and setting is supported entirely on the building steel, the total weight per unit being approximately 2,250,000 pounds. Some idea of the enormous amount of material contained in these four boilers can be had from the fact that, exclusive of the building supporting steel, superheaters and stacks, it required 110 cars to transport the material for the four boilers and settings. Shipments of material were started September 11, 1919, and the first boiler was completed and in service on October 1, 1920, with the balance going into service at intervals of approximately 30 days each.

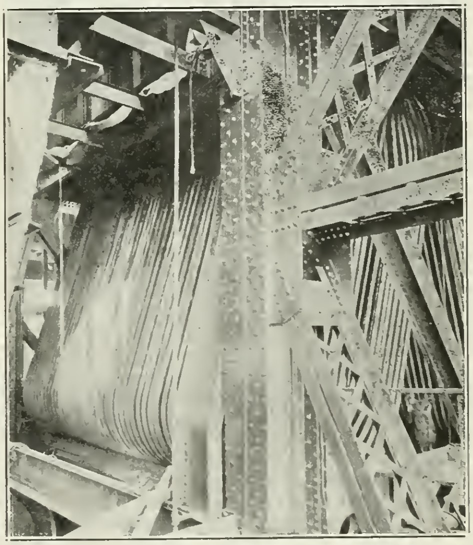


Fig. 1—Nest of boiler tubes.

The large main drums are 5 feet 0 inches inside diameter by 25 feet 10¾ inches long with 1 5/16 inch thick

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Abstract of paper presented before Engineers Society of Western Pennsylvania, entitled, "Description of Large Boilers Operating at the River Rouge Plant of the Ford Motor Company, complete paper and discussion will appear in April proceedings of that society.

shell plates. The shell is constructed with a top and bottom plate, both continuous, fastened with double riveted butt joints, with all rivets, both in the butts and head seams 1⅜ inches in diameter. All connections to the drums are either flanged or expanded. Each of the main drums is drilled for 738 tubes exclusive of the water balancing tubes connecting the top main drum and the tubes connecting with the steam collector drum. The top drums are also fitted with the main hangers, each of which consists of two ¾ inch web plates bolted to cast steel pads rigidly riveted to the top drum plates.

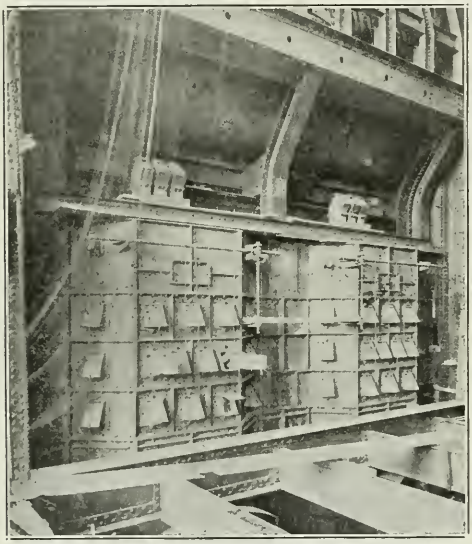


Fig. 2.

Each half of the boiler contains seven rows of tubes in the front pass, six in the middle and five in the rear. The tubes are spaced longitudinally, with such dimensions as to allow for easy removal and at the same time to admit of the introduction of the superheater elements, also allowing ample space for the passage of flue gas without too greatly increasing the draft loss.

In the previous description of the drum details, mention was made of the main suspension hangers. While these hangers are riveted securely in position on the top drums, the load of the boiler is transmitted to the overhead supporting steel in such a manner as to prevent expansion strains due to the elongation of the drums and the consequent increase of the center to center dimension between the supports. This is accomplished by means of the toggle connection on the expansion end.

The principle of this device is clearly shown in Fig. 3. The main pin, designed for bending, transmits the load from the hanger web plates to the toggle, which swings inside the box girder suspension beam. This bin is securely seated in the toggle itself so that any longitudinal motion of the drum causes the pin to move freely through the large holes in the web plates of the box girder, transmitting its motion to the toggle which, in turn, swings like a pendulum from the pin, mounted above the suspension beam.

In addition to the flexibility of the suspension, a great deal of attention was given to all other parts of the boiler where expansion strains might cause trouble. The position of the lower drums is maintained by forged head lugs bearing on lugs riveted to an outside girder in such a manner as to allow the lower drum to move freely in the direction of the main axis. The damper frames, which are 26 feet 9 inches in length, are held rigidly only at the center, and are fitted with three damper leaves having shafts with squared ends carried in spools which ride on rough roller bearings mounted in cast iron boxes bolted to the frame. This construction allows the three leaves to be actuated as one member and gives six points in the total damper where expansion may take place and results in a practically gas tight, freely moving mechanism, over a wide range of temperature.

The boiler is baffled for three gas passes, giving a total length of gas travel through the tube area of approximately 50 feet 0 inches. The baffle openings have not as yet been changed since the original design and no data is at hand which will warrant the assertion that the areas as installed will be adequate for the highest ratings that will ultimately be required. The evidence so far, however, points to the development of between 6,000 and 7,000 horsepower without excessive draft loss.

The main side walls of the boiler rest on heavy double girders framed into the building columns, having a top elevation of about 8 feet 0 inches above the ash pit doors. From the top of this girder, or the footing of the side walls to their top, is 48 feet 2¾ inches. There are two offsets in this wall which change it from a total thickness at the base of 33¾ inches to 22½ inches at the top section. A plan shows the inner face concaved to a depth of 9 inches for the lower two-thirds and to a depth of 4½ inches in the upper section. The lower sections are lined with a minimum of 13½ inches of first quality firebrick and the upper section with 9 inches. Between the firebrick and the face brick a 4½ inch insulating course of Cil-O-Cel brick was used, except in the zone of highest temperatures where it was omitted on the theory that preventing the radiation at this point might prove injurious to the firebrick lining. (See Fig. 4). There are three relieving arches in each side wall so placed as to provide for the repair of any spot in the high temperature zone.

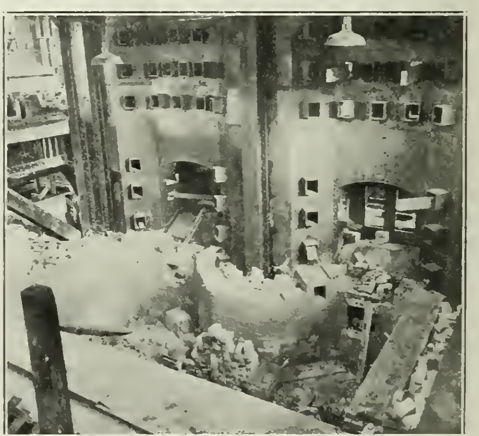


Fig. 3—The boiler under construction.

The position of these arches can best be seen in Fig. 1.

All steel members passing the face of this wall are designed with their inside surfaces theoretically in the plane of the outside surface of the brick, but in the case of the deeper girders the face brick was set back to allow a 4½ inch air space between the steel and the setting, thus completely air cooling these members.

Since starting the boilers, the furnace action on this wall has been very carefully observed. At the beginning there was a slight indication of longitudinal expansion visible at the corners, but this did not exceed one-quarter of an inch. Aside from this movement no defects have been noted and at the present time the brickwork apparently is in as good condition structurally as on the day it was finished. The heat action has thoroughly glazed the life of this detail.

The main supporting girder carrying this wall was designed with extreme care, the proportion of load on each web carefully computed and diaphragms used in an effort to cause both webs to deflect alike. It was also made extremely heavy and the deflection kept as low as possible.

The mixing oven furnace wall shows in plan as a W-shaped structure. It is also supported entirely on the building steel, but its height and weight is considerably less than the side wall. It is built with a batter on the inside, the latter being three-eighths of an inch to one foot, and is lined with 9 inches of first quality brick and insulated with Cil-O-Cel. On the outside there is a continuous cast iron jacket having the same contour as the wall itself, which supports the air doors through which the induced draft to the pulverized fuel is delivered. This jacket also supports the small Dutch ovens into which the blast furnace gas burners are introduced. The combined area of the air openings through the two walls of each boiler is about 60 square feet.

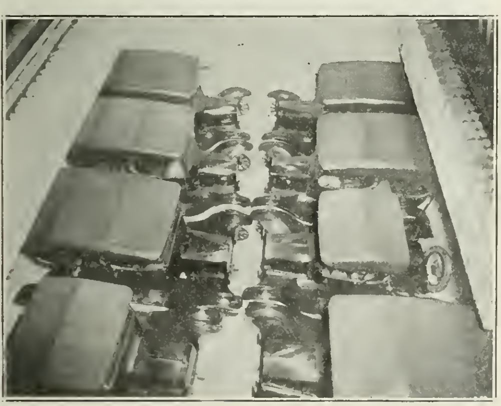


Fig. 4—Eight Ford cars in the boiler.

One of the most difficult features on the entire structure was the support of the main arches through which the pulverized fuel burners are introduced and which seal the setting from the burner elevation to the front side of the lower drums. These arches are 23 feet 0 inches in length, overhang the furnace about 4 feet 0 inches and are 9 feet 0 inches high from the bottom of the overhang to the top. A suspended arch construction was used throughout, i.e., moulded blocks of firebrick hanging on cast steel arch bars. Practically the entire load of the arch passes into the main supporting arch girder near its bottom chord, the top girder serving largely as a resistant to the tendency of the arch structure to topple over into the furnace.

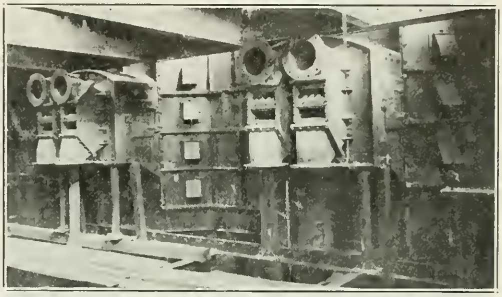


Fig. 5—Blast furnace gas connections.

Such a loading is necessarily extremely eccentric, but this was cared for by a rather complicated system of bracing over the top of the horizontal portion. The supporting girders were made very heavy, the unit stresses being kept down to 4,000 to 5,000 pounds per square inch. Resting on the horizontal framing are the sheath castings through which the pulverized fuel burners are introduced, one over each section of the "W" mentioned in the description of the mixing oven furnace wall.

Cast steel was selected as the best material for the arch bars on the theory of its longer life under severe heat action. These castings are introduced on six inch centers the entire length of the arch, that is, between each course of firebrick blocks.

The severe strain of the eccentric loading of the arch brick was greatly modified by utilizing the center front buckstay in such a manner that the supporting girders are held back to this member at their center, cutting their span of 29 feet 0 inches between the supports into two parts.

I have already indicated the position of the blast furnace gas burners. Four double burners are used, placed vertically below the pulverized fuel burners and introduced into the fronts of the small Dutch ovens built out from the lower portion of the mixing oven furnace wall. The furnace end of these small Dutch ovens is 24 feet 0 inches below the nearest point in the heating surface so that from the mouth of the burners to a point in mid-furnace, halfway between the lower drums there is a flame travel of nearly 30 feet 0 inches. This point is mentioned particularly on account of the interest to this community of furnace construction for the burning of blast furnace gas under boilers. There has been a marked tendency in Pittsburgh to increase the size of such furnaces and we believe that when the final results are available on the Detroit Boilers it will be shown that even for the burning of gas alone the furnaces in question are not too large.

The blast furnace gas burners are of the forced draft type, subdivided by vertical vanes so that the gas and air is introduced in thin vertical layers, the gas and air alternating. A system of regulating the air pressure to suit the gas pressure is being worked out and is apparently meeting with success.

The two sides of the boiler over the pulverized fuel burners and extending from the lower drum to the damper box are incased with removable casings. Six points were attempted in this construction:

1. Pleasing outside appearance.
2. Rigidity.
3. Tightness or freedom from air leaks.
4. Easy accessibility.
5. Safety in case of accidental high temperatures.
6. Heat insulation.

The casings are approximately 23 feet 0 inches square, so that in order to present a smooth external panelled appearance it was necessary to give considerable thought to the main ribs or supports. The method finally adopted was to use hollow air cooled members placed on 3 feet 5 inch centers and reaching from the bottom supporting girder to the top. These ribs are faced on the outside with a plate and angle construction so assembled as to provide a ledge against which the thin casing plates rest. These plates are plain rectangular sheared plates without punching and are held in place by outside jamb angles with mitred corners. There is ample clearance on the ledges, so that there is no possibility of accumulative or creeping errors. To remove the plates it is only necessary to take off only the exposed bolts on the outside.

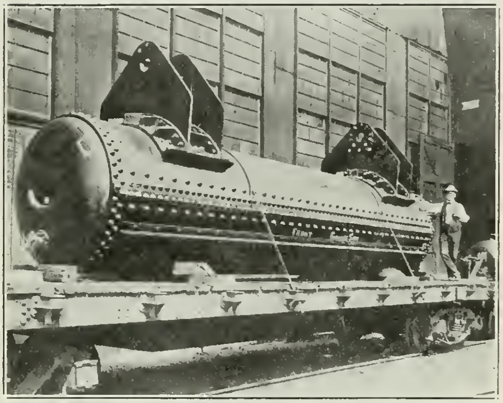


Fig. 6—Under shipment.

Surrounding the ribs on the inside and interlocking with the panel tile are special firebrick shapes which entirely face the inside of the casing with a firebrick lining about 5 inches thick. Between these tile and the casing plates a layer of Cil-O-Cel brick was introduced.

With the exception of the ribs there is no single piece in the casing weighing over 150 lbs. which, coupled with the facility for reaching it from the outside of the boiler, makes it possible to throw open any panel or the entire casing from top to bottom within a very short time. It has proven impervious to any discoverable air leaks, shows no signs of heating up, maintains its alignment and offers a smooth workmanlike appearance on the outside.

The ash pits and entire furnace bottom are suspended from the same girder that carries the main side wall. It will be noted that the central portion is arched longitudinally with the setting and the brick so constructed as to divert ash or dust falling from the flame zone into a hopper formation at each corner of the furnace. Each of these hoppers is equipped with a 4 foot by 3 foot sliding ash gate. A standard gauge track passes underneath the arched portion while two special ash tracks pass under the ash grates, providing a vertical discharge for refuse.

From time to time many questions have been asked concerning provision made for the expansion of the brick in these furnaces. The answer to this is that no provision was made at all, for under continuous high temperatures first quality fire clay brick contract rather than expand. The concave form of the inner face of the main side walls was put in to act as an arch against so-called tendency of the brick to creep toward the flame after shrinkage had taken place. We are aware that in some boiler settings expansion joints have been provided in brick walls having a large expanse, but we have always maintained that there was not sufficient expansion in fire clay brick and the other grades of brick entering into a boiler setting to make this necessary. It is essential that all steel supporting members subjected to heat be free to move in the direction of the long axis and that as much flexibility as possible be provided in the structure as a whole, but with this provision we do not regard the providing of expansion joints in the brick walls as necessary. It is quite possible that a little expansion occurs when the furnace is first heated up, but in the structures in question the general flexibility of the frame was sufficient, and had we the design to make over again we can see no reason why it should be changed.

The two fuels that have been used are blast furnace gas and tar, but it is the ultimate intention to burn the entire amount of blast furnace gas available, taking any load beyond this with pulverized coal. It has been estimated that for the night load the gas will be sufficient, but a considerable quantity of coal will have to be burned during the day to obtain the ratings desired.

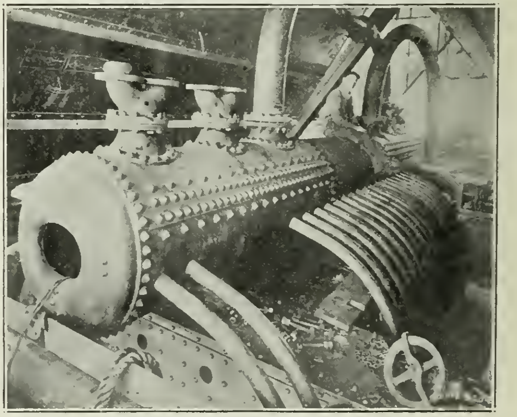


Fig. 7—Top of the boilers.

The No. 1 boiler has been operating continuously since October 1. It was started with gas alone and with a somewhat temporary and inadequate air supply for the gas burners developed, as near as could be estimated, nearly 175 per cent of rating. This matter was arrived at through the proportion of the load of the temporary boiler plant assumed by the No. 1 boiler. Later, tar burners were introduced near the bottom of the setting to further increase the rating and for one interval at least the whole load of the temporary plant was thrown on this unit. The temporary plant develops normally about 6,000 or 7,000 horse power and the No. 1 boiler assumed this entire load under the combined gas and tar firing, without difficulty. This data is not offered in any way as test evidence, but merely as a matter of interest pending further determinations.

The furnace action is particularly gratifying. The temperature developed by the tar shows with an optical pyrometer about 3,100 degrees at the end of the flame, but no severe action has as yet been noted on the brick.

Description of Super-Heaters.

The problem presented to the super-heater engineer in designing super-heaters for this installation was very exacting. The unusual arrangement of the boiler, the enormous size, the high pressure and super-heat specified, presented many difficult problems to overcome. A number of different designs were proposed, but the construction outlined below and illustrated in the slides, was selected because it seemed to best meet the peculiar conditions of this particular plant.

General Construction.

Each super-heater consists of three heaters, two 10 inches in diameter and one 12 inches, all approximately 23 feet long, together with the connecting elements.

Headers.

All three headers are located on top of the boilers, immediately above the steam generating drums, and below the steam collector drum. With this arrangement the super-heater headers with the unit joints, are placed entirely outside the hot gas bath and are accessible to inspection without entering the setting, even during operation. This is a highly important feature, particularly in large boilers which are kept in operation for considerable periods without shutdowns.

The 12-inch super-heated header is located in the center and the two 10-inch saturated headers one on each side. They are made of open hearth steel pipe, in accordance with A. S. M. E. specifications. The flange connections at each end are VanStone joints using extra heavy forged steel flanges.

A cross section of the headers is illustration in which shows the special joint construction. The connection between the units and the headers is of special interest because of the absence of expanded joints. The ends of the elements are upset forming a ball joint, the face of which is ground to a true sphere. The corresponding seat in the header for this ball joint is ground to a conical shape, thus forming a solid metal to metal contact, which is kept closed by means of a heavy clamp and bolt construction. The clamp rests on a unit washer, also ground to a spherical contour, making possible the self-alignment of the entire joint. The bolt is made of chrome nickel steel, having an ultimate tensile strength of not less than 100,000 pounds per square inch.

In general super-heater design there has been considerable controversy over the question of the relative position of the super-heater headers to the units. This controversy revolves mainly about the subject of drainability of the units. It is our contention that here reasonably pure feed water is used and the super-heater is designed to give a relatively high steam velocity through the units there there is no need to drain the elements, and by locating the headers at the top of the boiler all the joints are placed entirely away from the action of the hot gases. The top header construction also gives easy access to the joints at all times and facilitates the easy removal and replacement of any unit without entering the setting.

While there are undoubtedly cases where, due to local conditions, bad water, etc., it is advisable to build the super-heater with drainable units, where conditions are reasonably favorable we believe the advantages of the non-drainable type make it much to be preferred.

Powdered Coal Equipment.

The work done by our company on the River Rouge boiler plant covers the design and installation of the pulverizing plant and conveying system from the pulverizing plant to the boiler room and the design and equipment of the boiler furnaces.

Coal crushed so that it will pass a one and one-quarter inch ring is furnished to the overhead bunker —from the coaling station at the coke ovens. This overhead bunker has a storage capacity of 700 tons, which is equal to 17 hours storage with all four boilers operating exclusively on coal at 250 degrees rating.

The plant is at present equipped with four Raymond air separation mills of six tons capacity each. The coal is fed to these mills by gravity direct from the coal bunker through cast iron pipes and fed into the mills automatically in pre-determined quantities.

The coal, having been pulverized to a fineness so that 84 per cent will pass a 200 mesh screen is taken from the mill by air and gathered in the centrifugal collectors, from where it is discharged into 80 foot elevators, which deliver it into screw conveyors at a proper height for distribution to the top of the boiler bins. From the boiler bins it is fed to the furnaces by standard Lopulco feeders, of which there are 12 to each boiler, and through the standard Lopulco triplex burners, of which there are four to each boiler.

About 10 per cent of the air for combustion enters with the coal as the carrying medium from the feeder. The remainder of the combustion air entering through the air ports in the burner and through the auxiliary air openings in the front of the furnaces.

A study was made of the various systems being marketed for the burning of powdered fuel and it was finally determined to use the Lopulco system.

NEW COMPANY TO MAKE FERROZIRCONIUM.

The Industrial Bureau, Board of Trade, Baltimore, Md., has announced that the Zirconium Company of Amreica has acquired the plant of the Baltimore Rubber Tire Mfg. Co., Monument and Eleventh streets, Baltimore, and will manufacture ferrozirconium, and zirconium oxide. The property acquired consists of six buildings. The officers of the company are George F. Dixson, president; Philip C. Spencer, vice president; Charles W. Smiley, secretary, and Morris Meyer, treasurer.

Development of The Steam Turbine

General Classification of Steam Turbines in Relation to Their Special Characteristics—Respective Advantages of Impulse and Reaction Turbines.

By ROBERT JUNE.

PART II.

IT is not a very satisfactory proceeding to attempt a general classification of steam turbines because the various groups overlap to a considerable extent. However, there are sufficient differences in the characteristics of a number of well known turbines so that they may be conveniently classified according to the fundamental principles involved in their operation, as follows:

Impulse				Reaction	Combined Impulse and Reaction
Single Velocity	Multi-Velocity Stage	Single Velocity Stage	Multi-Velocity Stage	Multi-Velocity Stage	Multi-Velocity Stage
DeLaval	Terry Sturtevant Curtis (small type) Westinghouse	Kerr DeLaval Rateau	Curtis	Westinghouse-Parsons Allis-Chalmers Parsons	Westinghouse
Single Pressure Stage				Multi-Pressure Stage	

Impulse Turbines.

In turbines of the impulse type the complete expansion takes place in the stationary blades or nozzles and the steam is delivered to the moving blades with a velocity somewhat more than double that of the blades. The velocity of the jet is very high, from 2,000 to 4,000 feet per second, and for satisfactory economy the peripheral velocity of the wheel must also be very high. The passages between the moving blades are of uniform or even slightly increasing cross-section from inlet to outlet. The moving blades check and reverse the velocity of the steam current, thus creating a force against the blades which sets the rotor in motion.

If the entire pressure drop takes place in one set of nozzles and the resulting jet is directed against a single wheel, the turbine is classified as belonging to the single stage, single velocity group, of which the DeLaval class "A" turbine is a well known example.

We have just stated that for satisfactory economy the peripheral velocity of the wheel must be very high in turbines of this sort. However, it is possible to use a lower speed rotor by compounding the velocity. When this is done the jet issuing from the nozzle at a very high velocity is reflected back and forth from the vanes on the rotor to a series of fixed reversing buckets until all the available kinetic energy of the jet has been imparted to the wheel. An excellent illustration of this type of turbine is the Terry single stage machine.

Other means of combining low peripheral velocity and high efficiency is through pressure compounding. When this is done, expansion takes place in a series of successive nozzles instead of one nozzle. Thus, only a fraction of the available heat energy is converted into kinetic energy in each nozzle. For each set of fixed nozzles there is a corresponding rotor. To all intents and purposes this type of turbine consists of a series of single velocity impulse turbines placed side by side.

If we compound both velocity and pressure we have the multi-velocity and pressure type of which the Curtis turbine is the best known example.

Reaction Type Turbine.

In the reaction turbine, approximately one-half of the expansion in any one stage takes place in the stationary blades, imparting to the steam a velocity substantially equal to that of the moving blades so that it enters them without impulse. The remainder of the expansion takes place in the moving blades, the spaces between which gradually grow smaller from inlet to the exit side of the turbine, thus forming a ring of moving nozzles. The velocity imparted to the steam by reason of the expansion occurring in the moving blades produces a reactive force on these blades which turns the rotor of the turbine.

Only a very small portion of the heat energy imparts velocity in the first set of fixed blades or nozzles. As the expansion is very gradual a large number of alternate fixed and revolving blades are necessary to effect complete expansion.

Combined Impulse and Reaction Turbines.

In multi-stage work it has been found that the use of an impulse element for the first stage of expansion and the use of reaction elements for the subsequent stages forms an effective combination. The impulse element replaces without any appreciable sacrifice of economy a considerable number of rows of reaction blades in the least efficient part of the reaction turbine, and makes possible a shorter, and consequently, stiffer rotor. The Westinghouse-Parsons double flow high pressure turbine is typical of this class.

Respective Advantages of Impulse and Reaction Turbines.

The impulse and the reaction turbines represent two schools of engineering development, each of which secures practically the same result as the other, but by slightly different means. It is fully as difficult to compare the advantages of one type of turbine over the other as it is to compare the respective advantags of horizontal and vertical water tube boilers. While many engineers can offer excellent reasons for preferring one type of turbine over the other, the fact remains that to a great majority of engineers these reasons are comparatively unimportant, and their preferences will depend not upon general considerations, but upon the conditions obtaining in their individual plants.

It is plain that in the impulse type, because of the considerable differences in pressure which exist between adjacent stages and the fact that steam leakage increases as the square of the pressure drops, that it is very important that means be devised to minimize the leakage and result loss of efficiency. It has, therefore, been the universal practice with this type of turbine to employ a rotor built up of disks mounted on a shaft of small diameter in order that the clearance between the shaft and the diaphragm separating the pressure chambers may be as small as possible. This construction results in a light shaft which may develop deflection seriously. It is also claimed that the disks of the impulse turbine are subject to frequent temperature changes, and because of these changes and the high velocities at which the turbine operates, the disks are to some degree liable to rupture.

An advantage claimed for the impulse turbine is that because the blades are very much larger and very much fewer in number than the reaction blades, that there is considerable less difficulty in maintaining them.

For the reaction turbine it is claimed that the rotor, being made up of a comparatively thin cylindrical drum of considerable diameter with rings of large bore, that the internal strain in the disks is negligible. It has also been said that the drum construction of the rotor makes the reaction turbine very much more accessible for examination and repair.

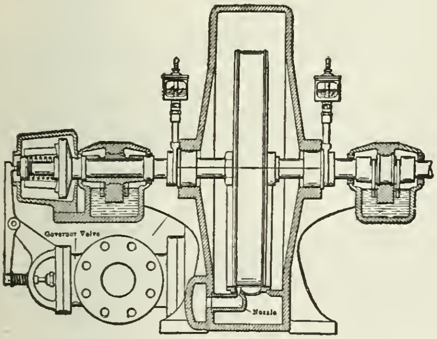


Fig. 1—Section through single-stage Terry steam turbine.

It is well to remember, however, that the several types of turbines are made by concerns of the very highest standing in the engineering world, and this fact may be practically considered as a guarantee of the successful operation of the turbines produced by these manufacturers.

Terry Non-Condensing Turbine.

In the Terry non-condensing turbine, Fig. 1, courtesy Gebhardt, the compounding of the velocity permits of much lower peripheral velocities than with the single velocity type. The rotor, a single wheel consisting of two steel disks held together by bolts over a steel center, is fitted at its periphery with pressed-steel buckets of semi-circular cross section. The inner surface of the casing is fitted with a series of gun metal reversing buckets arranged in groups, each group being supplied with a separate nozzle. The steam issuing from nozzle N at very high velocity, strikes one of the buckets on the wheel, and since the velocity of the buckets is comparatively low, is reversed in direction and directed into the first one of the reversing chambers. The chamber redirects the jet against the wheel, from which it is again deflected; this is repeated four or more times until the available energy has been absorbed by the rotor. Terry turbines are made in a number of sizes varying from 5 to 800 horsepower, and operate at speeds varying from 210 feet per second in the smaller machine to 260 feet per second in the larger.

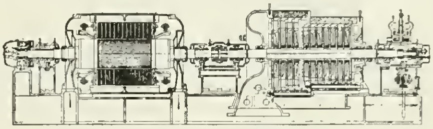


Fig. 2—Section through 1,000 kw. Kerr "Economy" Rateau type turbine-generator.

Kerr Turbine.

The Kerr turbine, Fig. 2, is of unusual design in that it is built up in sections, the casing comprising a steam end, exhaust end, and whatever number of intermediate stages are best suited to meet the individual condition. The rotor consists of a series of steel disks, mounted on a rigid steel shaft. A series of drop forged steel buckets is secured to the periphery and riveted in dovetailed slots. The tips of the buckets are riveted to a shroud ring, thereby insuring a rigid and positive spaced construction. The stator is made up of a number of arched cast iron diaphragms with circular rims tongued and grooved, and bolted to steam-end and exhaust-end castings.

The operation is as follows: Steam centers the turbine through a double-beat balanced poppet valve, the stem of which is connected through levers to the governor, to the circular cored space extending around the steam "enc casting." This space acts as an equalizer and insures uniform admission to the first set of nozzles. Partial expansion takes place through the first set of nozzles and the kinetic energy is imparted to the rotor through the medium of the vanes. Steam leaves the buckets at a very low velocity and is again expanded through the second set of nozzles in the diaphragm. This process is repeated in each stage.

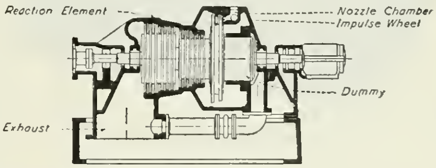


Fig. 3—Section of a combination impulse and reaction single-flow turbine.

Westinghouse Turbine.

In the Westinghouse impulse and reaction turbine, single-flow type, Fig. 3, the substitution of the impulse element for the high-pressure section of reaction blading has essentially no influence on the net efficiency of the turbine. That is to say the efficiency of the impulse wheel is about the same as the least efficient section of reaction blading. This design is attractive, however, in that under some conditions it shortens the machine and gives a stiffer design of rotor.

The entering steam is confined in the nozzle chamber until its pressure and temperature have been materially reduced by expanding through the nozzles. As the nozzle chamber is cast separately from the main cylinder, the temperature and pressure differences to which the cylinder is subjected are correspondingly lessened.

Westinghouse Double-Flow Turbine.

The maximum economical capacity of a single-flow turbine is limited by the rotative speed. The economical velocity at which the steam may pass through the blades of the turbine depends on the velocity of the moving blades. The capacity of the turbine depends on the weight of the steam passed per unit of time, which in turn depends on the mean velocity and the height of the blades. For a given rotative speed, the mean diameter of blade ring practicable is limited by the allowable stresses due to centrifugal force, and there is a practical limit for the height of the blades.

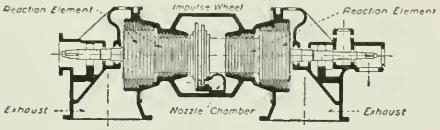


Fig. 4—Section of a double-flow turbine.

Now, if we make the rotative speed only half as great, the maximum diameter of the rotor may be doubled and, without increasing the height of the blades, the capacity of the turbine will be doubled. So with the single-flow steam turbine as well as with the single-crank reciprocating engine, there is a practical limiting economical capacity for any given speed. If this limit is reached with a single-crank reciprocating engine, we may produce a unit of double the power at the same speed by coupling two single-crank engines to one shaft.

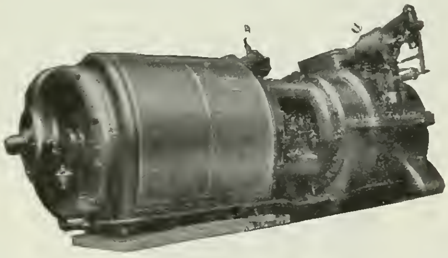


Fig. 5—1,000 kw., 60-cycle Curtis steam turbine with automatic extraction device.

The Westinghouse double-flow turbine is in effect, as will be seen from Fig. 4, two single-flow turbines made up in a single rotor in a single casing with a common inlet and two exhausts. Steam enters the nozzle chamber, acts on the impulse element, and then the current divides, one-half of the steam going through the reaction blading at the left of the impulse wheel; the remainder passes over the top of the impulse wheel and through the impulse blading at the right..

Curtis Turbine.

All General Electric Curtis turbines, ranging from the very small direct current machines to the huge turbo-alternator of 40,000 kw, are of the impulse type. So many changes are made in these, as well as in other turbines from year to year, that descriptions can only be given in the most general terms.

In practically all sizes the high-pressure stage comprises a set of nozzles and a single wheel carrying two rows of buckets. Subsequent stages have but one row of buckets on a single wheel, except in the low-pressure element of the compound cylinder units where there are two wheels per stage, each with a single row of buckets. The steam flow is axial in all machines.

The speed in the smaller machines is controlled by a centrifugal governor, mounted on the end of the main shaft, which actuates a throttling valve of the balanced poppet valve type.

A relay governor of the hydraulic type controls the large turbo-alternators. Oil is fed to a cylinder under pressure through a pilot valve under control of the main governor. The piston rod of the cylinder contains a rack which meshes with the pinion on a camshaft, which in turn lifts the individual control valves, as determined by the spacing of the cams.

Bleeder Type Turbine.

One of the most interesting developments of the steam turbine is the so-called Bleeder, or Extraction type. Steam is automatically bled from an intermediate stage for heating or manufacturing purposes after it has passed through and done work in the high pressure stages of the turbine. Steam is usually bled at from one to 15 pounds pressure in quantities from a minimum amount up to the throttle capacity of the turbine.

It is probably due to the demands of the textile industry more than any other that this type of turbine was developed. The steam so bled is absolutely free from oil and may be used for dye vats, bleaching, slashing, etc., without danger of injury to the product.

In conclusion, it has only been possible here to describe in rather general terms the principles of operation and the details of construction by which the various turbines differ from each other. For a discussion of the advantages and disadvantages of steam turbines reference should be made to Part I of this article published last month. It seems well in closing to emphaize the fact once more that builders of turbines generally occupy a very high position in the engineering field, and that entire dependence can, as a general proposition, be placed upon the statements and recommendations of the various makers.

CLOSE BROKEN HILL PROPRIETARY PLANT

A cablegram to the Bureau of Foreign and Domestic Commerce from Trade Commissioner A. W. Ferrin at Melbourne, Australia, reports that the New Castle Steel Works of the Broken Hill Proprietary Company, Ltd., has been closed on account of the strikes at the mines of the company. The New Castle Steel Works employs about 5,000 men. During the year ending May 31, 1920, the company produced 296,000 tons of pig iron from two furnaces with a combined capacity of 1,000 tons daily.

Principles Underlying the Economical Firing of Boilers

Selection of the Proper Fuel and Type of Furnace It Should Be Burned in Are the Most Important Items—Boiler Regulation by Instruments Also Essential.

By CHARLES LONGENECKER.

THE degree of economy obtained in firing any boiler is best measured by the cost to evaporate 1,000 pounds of water in that particular boiler. This cost will include not only fuel but also labor, repairs, materials, etc. Too often stress is laid only on the amount of fuel burned, but this is by no means the sole consideration. In some instances where the furnace design is faulty the repairs to brick work may increase to alarming proportions, or when the coal is of a poor quality excessive "clinkering" may cause a high labor cost. At certain times in recent years the fuel market has been in a chaotic state and the supply interrupted so that in some plants it was impossible to obtain the class of fuel usually burned. In such cases the use of a substitute fuel for which the furnace was not adopted caused an increase in operating costs.

The item of greatest import will normally be the item covering fuel. This will vary from 25 to 75 per cent. depending on the type of plant. In large central stations with up-to-date appliances, this item will be low while in the small isolated plant it will be high.

The principles governing the economical burning of fuels are generally well appreciated, but this cannot be said in regard to their application. The failure to differentiate between the principle and its correct application is the one outstanding reason why there is so much mediocre furnace construction, and hence indifferent efficiency. It does not require experience to understand the principle, but it does require experience to apply it. The most important principle tending towards the economical firing of boilers—or furnaces of any description—is the maintenance of uniform conditions. Practically every invention covering an improved method of feeding coal, or any fuel, consciously or unconsciously, works to this end. Thus "hand-firing," except in rare cases, lacks all pretense of uniformity. Generally as we get away from dependence on the "human factor" we approach a more regular and uniform condition. The stoker has largely superseded hand-firing for the reason just stated. Oil, gas and powdered coal can be introduced into a furnace with the utmost exactness and hence maintain a steady temperature and an unvarying atmosphere. The various methods of boiler control all aim to maintain uniformity in the combustion chamber and for any particular variation in steam demand the air supply, damper opening and pressure in the chamber are uniform, for that particular variation. To detect any departure from the desired conditions, we have the draft guage, CO_2 recorder, etc. As regards brickwork it will stand up much longer where it is subjected to a constant temperature. It is varying temperature that causes the rapid deterioration, due to contraction and expansion. One of the most important requisites is the uniformity of air supply and distribution in relation to the coal. This, then, introduces the record principle which concerns the union of the oxygen of the air with the carbon and hydrogen of the coal.

It is generally stated that one pound of coal requires so many pounds of air to burn it. This is all well enough as far as it goes, but it does not go very far. In other words, it does not mean anything except from a theoretical standpoint. Any coal that is burned with the theoretical amount of air will, in practice, be very inefficiently consumed. The nearest approach to the theoretical will be when the coal is burned in powdered form, but here, too, there will be an excess amount of air. In burning this pound of coal the steps are more complex than many appreciate. The fixed carbon "must be burned and also the volatile combustible." One portion of the oxygen of the air unites with the "fixed carbon" a solid, while another portion combines with the carbon and hydrogen of the volatile. It may be interesting to see what these proportions are. The following is the "proximate" and "ultimate" analysis of a Pittsburgh vein bituminous coal:

Proximate		Ultimate	
Moisture	2.29	Carbon	79.53
Volatile	35.93	Hydrogen	5.08
Fixed carbon	55.87	Oxygen	6.51
		Nitrogen	1.62
Ash	5.91	Sulphur	1.21
		Ash	6.05

The total amount of air required to burn one pound of this coal, disregarding the sulphur, will be

Hydrogen	1.48
Carbon	9.61
	11.09

To burn the fixed carbon, 6.43 pounds of air will have to be furnished. The volatile combustible will require (11.09-6.43) 4.66 pounds of air. Expressed as a percentage, 42 per cent of the total air to burn coal must be supplied to the carbon and hydrogen existing in the volatile matter.

The steps in the combustion of the fixed carbon are generally recognized to be as follows: The carbon is oxidized to CO_2, which, coming in contact with hot carbon, is reduced to CO, according to the equation CO_2 C = 2 CO. The CO formed is again oxidized to CO_2. There exists some doubt concerning the exact order in which the carbon is oxidized, but the steps just given are accepted for want of any more conclusive evidence to the contrary. If there are thin spots in the fuel bed the carbon may pass away, as CO_2, and not be reduced to CO. Where the CO_2 is reduced and 2 CO is formed it is evident that we have to further oxidize the carbon. Thus, besides the volatile combustible originally in the coal, another gas, requiring further oxidization, is supplied by the burning of the "fixed carbon." Technical Paper No. 137, issued by the Bureau of Mines, gives, on page 63, the composition of the gases at the surface of a 6-inch fuel bed of a Murphy stoker. There are:

CO_2	6.2 per cent
O_2	3.4 per cent
CO	13.4 per cent
CH_4	1.0 per cent
H_2	9.0 per cent

In this instance 6.2 cu. ft. of every 100 is completely oxidized and will not be reduced. The 13.4 cu. ft. of CO must combine with an additional amount of oxygen.

The carbon in 6.2 cu. ft. of CO_2 is:

$$\frac{3}{11} \times 6.2 \times 1.98 = 3.348 \text{ oz.}$$

While the carbon in the CO is

$$\frac{3}{7} \times 13.4 \times 1.26 = 7.236 \text{ oz.}$$

The total carbon in these two gases is then 10.584 oz., of which 68 per cent is in the CO and must be further oxidized.

The point to be emphasized is that the largest portion of air furnished combines with the carbon existing in the gases and only a relatively small portion with the carbon existing as a solid. The total amount of hydrogen, except that portion in the form of water is, of course, in the gaseous form. The combustible gases arise from the fuel bed, according as the method of firing differs. A stoker fired furnace gives off its gases in a manner far different than a hand-fired, and in a powdered coal furnace the conditions are far different from either. Whatever the method of firing, it is evident that to secure the most thorough mixing of air and combustible gases the design of the combustion chamber is a controlling factor. The volume must be large enough to give the gases time to combine. The time factor in early installations was disregarded and today is not given the consideration it should have. In a design of furnace recently presented the distance between the grate bars and the first row of tubes was 26 inches. The results from such a design are evident.

Another factor of great importance is the maintenance of a temperature sufficiently high to assure quick ignition and complete the combustion before the tubes are reached. This is a question of the design of the setting and the draft. The velocity of the gases must not be too rapid, which again introduces the element of time. Some years ago the consumption of 25 pounds of coal per square foot of grate surface was a fair average, while today it is not uncommon to burn 40 or 50 pounds, and in many cases 65 pounds. Boilers of 150 to 200 per cent are very frequent. To obtain high ratings the volume of the combustion chamber is again a most vital factor if economy is to be secured. This is particularly true where high volatile coals are to be burned.

The design of the combustion chamber will be governed by a number of variables and each setting should be constructed according to the particular conditions under which the boiler will operate. In the early application of powdered coal to boilers, there arose many difficulties which were caused by improper furnace construction. The attempt was made to apply the coal to settings which had been built for either stoker or hand-fired furnaces and the results were in most cases disastrous. Trouble was experienced with the tubes, which were in many cases cooled with ash and furthermore the brickwork did not stand up. Later on the form and proportions of the setting were radically changed and operating conditions revolutionized. The idea of the day is to make the entire volume "effective" and eliminate eddies and pulsations. In the limited space available for this discussion, it is impossible to enter into details regarding design of combustion chambers, but two important features may be mentioned:

With a desire to economize in the installation of a boiler plant in a majority of cases the brickwork, etc., is reduced to a minimum. The result is a furnace too small for economic results. In other words, economical operation is sacrificed for a low first-cost and the loss in a year would pay many times over for a correct and adequate installation.

The use of first-class material in the setting is advisable and will pay dividends over the selection of an inferior grade. Thus with thick walls backed by a good insulating brick will prevent heat losses otherwise unavoidable. The radiation losses generally run about 5 per cent of the rated boiler output and any means spent to reduce this will aid in increasing output.

Probably one of the most instructive means for illustrating the pains that are taken in order to secure economy is a visit to one of the modern central stations. The majority of such stations have adopted some system of boiler regulation, previously alluded to. Such a system eleminates the "human factor" in controlling the combustion of the coal. Any one conversant with boiler firing recognizes the necessity of obtaining the correct pressure in the combustion chamber. This is hard to do where dependence must be placed on some employee. As the demand for steam varies the furnace conditions vary and there must be a means of simultaneously adjusting supply with demand. As the coal is increased or decreased the air supply is proportionately increased or decreased and the stack damper opened or closed, accordingly. With such changes the pressure in the furnace is maintained constant at approximately what is termed "balanced draft." If the pressure in the combustion chamber is too great there will be destruction of the brick work, while if the pressure is below atmospheric cold air will be drawn in. The means for effecting these adjustments are all synchronized and are controlled by the demand for steam.

A great many boilers, in plants of large size, are now equipped with super-heaters and all boilers should be. It is estimated that the following saving can be made by super-heating the steam 150 degrees:

In simple engines	20 to 25 per cent
Compound engines	15 to 20 per cent
Triple expansion engines	14 to per cent
Unaflow expansion engines	about 10 per cent

With such savings possible it is hard to understand why only 15 per cent of all the steam generated is super-heated.

There is no factor of greater importance than the "Herman Factor," as on it depends, according to David Moffa Myers, "one-fourth of the factory's

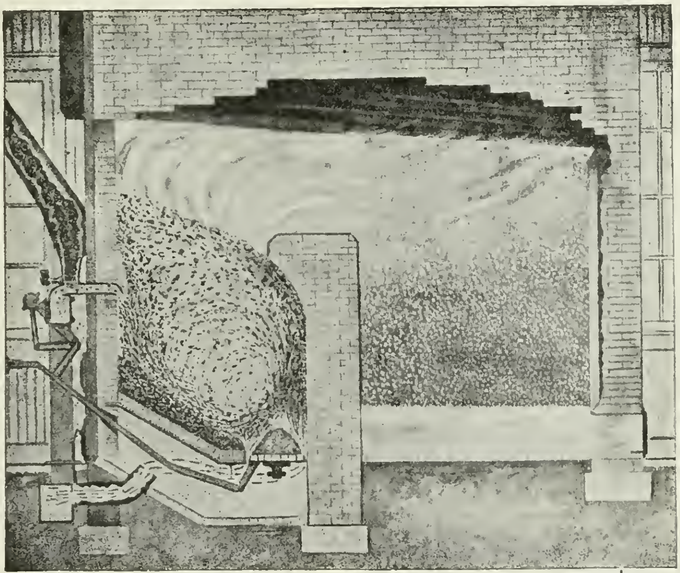
(Continued on page 238)

Grateless, Smokeless, Automatic Furnace for Steam Power Production at the Mines

Radical Revolution in Power Generation by the New Method of Burning Coal, Not Only Promises Higher Efficiencies and Greater Economies, but Is Expected to Solve the Smoke Problem.

THE announcement by the Stephens Engineering Company of the development of a new process of combustion is attracting considerable attention since it has become known that the Stephens Process has been worked out in application for use in land boilers to a state of perfection that warrants putting it on the market for commercial use in the generation of steam.

The accompanying is an illustration of the operation and a brief description of the new invention, which is known as the Stephens Process of Combustion, and which is protected by United States and foreign patent rights.



Showing the process in operation under a standard water tube boiler of 200 hp, at the Stephens Laboratory, United States Bureau of Mines, Pittsburgh, Pa.

The downward sweep of air coming through the front of the furnace carries measured quantities of fuel consisting of dust, fine particles up to pieces three-quarters of an inch in size. The dust and fine particles burn in suspension. The larger particles cast upon the inclined bed, when incandescent, flow toward the bridge wall, where the bed is disrupted by an oscilliating platform, and an upward sweep of air carries the disrupted constituents of the flowing mass along the bridge wall to the overhanging arc, which deflects them back to the front wall of the firing chamber, and, dropping, they re-enter the downward sweep of air and fuel and in this manner constitue an active vortex, in which not only all coal, but also all of the smoke is completely burned, and the vortex at all times operates uniformly even though the boiler is suppressed or forced in order to lower or raise the steam generation.

Statement, by W. G. Howard, sales manager, Stephens Engineering Company:

One of the most fertile fields of the expert is that relating to the economical use of coal. Never in history has the importance of conserving fuels been so sharply emphasized as at present. In view of the vast importance that suddenly became attached to conserving coal as an event of war, it should now rank ahead of every other branch of engineering, concerned with the production of light, heat and power.

Insofar as boilers are concerned the Stephens Engineering Company has developed a process that will help to relieve the situation. Briefly stated this process is a new principle based upon the discovery that it can carry coal into suspension with less air than is required to burn it. This permits setting up a vortex as above described in which all the volatiles and coke are completely and efficiently consumed before they reach the boiler tubes, and thus most certainly beyond the tubes—the stack. There is also an arrangement that saves the developed heat in the ash before they are dumped into the ash pit.

Fuel conservation depends upon the education of all those who have to do with fuels—producers, transporters, and those engaged in the final employment of fuels for useful purposes.

As a base to start from there is one general rule that applies to all furnaces for boilers; namely, that furnace is the best furnace which completely and efficienty consumes all of the combustibles with the least surplus of air.

The Stephens Engineering Company in engaging to fulfill the theoretical and practical requirements for a satisfactory, efficient and economical firing system for boilers, has constructed a stoker of the utmost simplicity of design to the end of, first, burning perfectly all of the coal completely and efficiently, and, second, getting the maximum of heat out of each pound of coal in the furnace area, and, at the same time, radiating and conveying that heat intact to the exact point where the heat is desired.

We have thus achieved scientific combustion as follows: without grates — without arches — without smoke.

Our boiler furnace is:

1. Automatically self-feeding.
2. Easily regulated to maintain any temperature desired.
3. Completely burns every particle of combustible and also saves the heat in the ash.
4. Keeps clean the entire furnace atmosphere by absolute smokelessness, saving waste, annoyance and damage.
5. Completely and efficiently burns cheap grades of slack coal as economically as high grade coal without any structural change in the furnace or its equipment, and without any extra attention whatever.
6. Can at any time be speeded up or down with complete efficient smokeless burning of the fuel in either case.
7. Forcing to meet sudden demands is practically instantaneous.
8. There are no clinkers.
9. The ash can be disposed of automatically after first fulfilling condition number three.

The company's laboratory is equipped with a standard water tube boiler and all facilities for making tests to demonstrate the above claims and also to show the efficiency of the process in burning lignites, coke braize, anthracite culm and the like, all in the same furnace.

PRINCIPLES UNDERLYING THE ECONOMICAL FIRING OF BOILERS.

(Continued from page 236)

yearly coal bill." In his book, entitled "Factory Power Plants," Mr. Meyers states "The firemen in our boiler plant will, in the future, be far better paid, their working hours will not be excessive, and the boiler rooms will be better ventilated. The firemen will be given a direct financial interest in eliminating the preventable waste of fuel; they will receive specialized education to enable them to produce very large economies that only await such educational incentive. They will become skilled workers who will annually save for their companies 10 and 20 times the increase in their wages."

Any discussion of the utilization of fuels is not complete unless it embodies a discussion of the furnaces in which the particular fuel or fuels are burned. The fuel is, so to speak, merely the container in which the heat is carried. Its utilization is altogether a function of the furnace, which may be of correct or incorrect design. Whether the fuel is a gas, a liquid or a solid is no criterion of the satisfaction it will give. It is merely a question of adaptability. The chemical composition of the fuel is an index to the potential heat contained therein per unit, but it does not indicate what results may be secured in the combustion chamber. Likewise the calorimeter tells how many Btu. are contained in a unit quantity of fuel, but it does not tell the cost to heat a unit quantity of material with the particular fuel. Experience points the way and is the only guide in the selection of the proper fuel and the type of furnace in which it should be burned.

THE LOGIC OF ROLL DESIGN.

(Continued from page 211)

Practically the only work done on the closed part of the groove is to reduce the height of the flanges to take care of the elongation of the sides of beam to compensate for the elongation of the web, due to its reduction in thickness. Beams are sometimes rolled diagonally to increase this slabbing action of the tongue roll.

The most difficult section to roll is one in which thin flanges must be produced in some part of the section, on which it is impossible to bring any of these various slabbing actions into use. Under this condition these flanges must be worked up gradually, requiring a much thicker billet to start with in order to get flanges to height.

Other sections which apparently could not be rolled in their finished shape are rolled, opened out into a shape that will deliver from the rolls and then bent up into their final shape in a bending pass; a good illustration of this type of section is sheet piling.

In designing all sections, the roll designer must use good judgment in proportioning the reduction of section in order that the bar may deliver straight and not be robbed in spots by wire drawing effects.

The object of these articles was to demonstrate the Principles governing design, rather than any particular Form of design. As the form will depend upon the conditions existing in each individual mill.

ENGINEERS DISCUSS STEEL TOPICS.

IRON and steel topics played an important part in the winter meeting of the American Institute of Mining and Metallurgical Engineers, February 14-17, at the Engineering Societies building, New York. Two sessions on Tuesday were devoted entirely to the discussion of subjects touching upon the metallurgy and manufacture of iron and steel, while on Wednesday two sessions were devoted to the presentation of detailed information on the breakage and heat treatment of drill steel. The discussion on this subject led to a number of important phases of the manufacture of drill steel and resulted ultimately in a resolution to the effect that the American Institute of Mining and Metallurgical Engineers establish a board in co-operation with other engineering societies and government agencies to investigate the breakage and heat treatment of rock drill steel and other steels subjected to similar stresses. This resolution was unanimously adopted and will go to the board of directors of the institute for action.

Another subject which received attention during the meeting was that of industrial relations, one entire session and parts of others being devoted to employment and welfare problems. Other topics discussed during the meeting dealt with nonferrous metallurgy, nonmetallic minerals, mining and milling, coal mining and petroleum ad gas.

The annual banquet was held at the Waldorf-Astoria Hotel last Wednesday evening. W. L. Saunders, Ingersoll-Rand Company, New York, presided as toastmaster. Herbert Hoover, retiring president of the institute, delivered a brief address devoted almost entirely to a review of the activities of the organization during the past year. Edwin Ludlow, New York, incoming president, emphasized the importance of the labor problem.

CONVENTION CALENDAR.

April 20-21—National Metal Trades Association. Annual convention, Astor Hotel, New York. Homer D. Sayre, Peoples Gas Building, Chicago, is secretary.

April 21-23—American Electrochemical Society. Spring meeting at the Hotel Chalfonte, Atlantic City, N. J., Joseph W. Richards, Lehigh University, Lehigh, Pa., is secretary.

May 5-6—British Iron and Steel Institute. Spring meeting at the Institution of Civil Engineers,Great George stret, London, S. W. 1. The secretary is George C. Lloyd, 28 Victoria street ,London, S. W. 1.

May 9-10-11—American Association of Engineers.

Annual convention ot be held in Buffalo. National association headquarters, 63 East Adams street, Chicago.

BOILER HOUSE MANUEL.

A reference manual to aid the owner, manager and operator in securing and maintaining boiler plant economy entitled "Finding and Stopping Waste in Modern Boiler Rooms," has been published by the H. S. B. W. Cochrane Corporation to be sold at $1.00. It is one of the most interesting books published on this subject.

FOREIGN RELATIONS

NEW ARMOR PLATE FOR GOVERNMENT STEEL FOUNDRY IN CHINA.

The Yawata Steel Works, the Government foundry, is to have a special department for the production of the extra thick steel plates required in the construction of the new war ships designed to constitute the first line in the future navy, states the Far Eastern Review. It is stated, however, that it will be about two years before the prescribed output of 90,000 tons per annum will be attained because of the inexperience of the workmen.

TOKYO MUNICIPALITY PLANS NEW BRIDGES

According to the Japan "Advertiser," a scheme at an estimated cost of 1,400,000 yen is planned by the municipality of Tokyo for the construction of 1,000 bridges. Three hundred of the bridges now of wood are to be replaced by iron-framed structures.

AMERICAN BOILERS FOR BRITISH COLONIES.

American manufacturers of boilers for marine and stationary engines should bear in mind that boilers intended for British Malaya must meet the specifications required by the British Board of Trade. It is emphasized by Consul General Dickson that though the American specifications may differ from the British merely in the matter of the thickness of the head, such variations should be adjusted by American manufacturers. A number of power plants have recently been installed in this district, and as it is reasonably certain that the market for boilers is on the increase it is of vital importance that the American product should conform to British requirements.

DEMAND FOR TIN PLATE.

While the demand for tin plate in Japan is annually increasing, according to "Finance and Commerce," owing to the development of the petroleum and canned food industries, the manufacture of tin plate is difficult to carry on, the producers being unskilled and the cost of production high. During the four years 1911-1915 the annual importation of tin plate averaged about 26,000 tons, valued at approximately 4.000,000 yen. The following figures indicate the increase in quantity and value which has taken place since then:

	Tons	Yen
1916	39,305	10.083,697
1917	26,848	11,725,622
1918	29,311	20,836,713
1919	37,336	17,515,565

INDUSTRIAL DEVELOPMENT IN CHINA.

In spite of many hindrances, industrial progress in China continues. The Ministry of Agriculture and Commerce recently compiled statistics showing the number of new companies registered in Peking, as follows:

Industry	No. of companies	Total Capital
Cotton mills	16	$ 6,673,600
Mining companies	12	9,472,785
Electric	26	3,123,785
Transportation	18	6,866,000
Commercial	15	13,373,000
Agricultural	16	8,629,000
Manufacturing	53	21,721,300
Fishery	3	1,055,000
Miscellaneous	8	2,463,000

The largest number of these enterprises are located in Chihli, while those in Kiangsu Province rank next in number.

RICH TUNGSTEN ORE IN ARGENTINA.

Trade Commissioner George S. Brady has forwarded a sample of tungsten ore from the Province of Catamarca, Argentina. The Bureau of Mines has made analysis of this ore which shows that it contains 64.46 per cent wolfram, 10.95 per cent silica plus insoluble matter, and considerable calcium carbonate. In other words, the material is about 80 per cent scheelite, 11 per cent silica, etc., and 9 per cent soluble matter, mostly calcite. The name of the owner is not given by Mr. Brady, but if any American companies are interested in Latin American Division of the Bureau of Foreign and Domestic Commerce can obtain a report upon the matter.

NEWCASTLE STEEL WORKS.

An expenditure of about £3,500,000 has been decided upon by the directors of the Broken Hill Propriety Company (Ltd.) for extensive additions to the present plant at the Newcastle Steel Works, where already 5,000 men are employed. The demands of the Commonwealth for adequate supplies of iron and steel for newly established industries as well as increased orders from abroad brought about this decision. Two representatives of this company have been sent to the United States for the purpose of gleaning information relative to the cost of the required additional machinery, according to advices from Consul General Sammons, of Melbourne. All additions are planned to be completed in two years. Another blast furnace, making four in all, is to be erected, together with the added number of coke ovens required. A by-product plant will be used in connection with the coke ovens. Other additions include a duplex steel plant, a continuous mill for the rolling of steel bars and billets, a duplication of the present rod mill, and a sulphuric-acid plant for the supply of acid in connection with the production of sulphate of ammonia and for galvanizing.

FRENCH STEEL AND PIG-IRON PRODUCTION FOR FIRST NINE MONTHS OF 1920.

(Consul E. L. Ives, Paris, Nov. 3, 1920.)

The production of pig iron during the first nine months of 1920 has shown a steady increase, from 195,116 metric tons (metric ton=2,204 pounds) in January to 347,451 metric tons in September, with the exception of the month of April, the production of which amounted to 179,464 metric tons. (For other reports on this industry see Commerce Reports for May 14 and July 8.)

The monthly production of pig iron in metric tons, as estimated by the Comité des Forges de France (provisional figures), is as follows: January, 195,116; February, 205,227; March, 198,445; April, 179,464; May, 223,510; June, 270,756; July, 299,980; August, 321,293; September, 347,451.

Steel Production During the First Nine Months of 1920.

The tonnage production of raw steel (ingots and castings) during September, 1920, shows an increase over the amount produced in January of 104,471 metric tons.

NEWS OF THE PLANTS

The Lebanon Valley Iron & Steel Company, Duncannon, Pa., is making a number of extensions and improvements at its plant for increased production and operating efficiency. The work will be completed at an early date, and the finishing mill placed in service. This partial operation will be followed by the entire plant shortly thereafter.

The Ashtabula Steel Company, Ashtabula, O., has construction under way on a new sheet mill plant, and proposes to have the works ready for service early in the summer. The new plant will consist of eight sheet mills, eight combination furnaces using powdered coal as fuel, two continuous annealing furnaces and two galvanizing pots. The power installation will consist of a duplex engine, 28x36 inches, operating at 150 r.p.m, with gear reduction of 5 to 1.

The Tennent Steel Casting Company, Tacoma, Wash., has perfected plans for the establishment of a new branch plant at Centralia, Wash., where a large part of production will be given over to the manufacture of castings for automobile and other service. The company will remove a portion of its present works to the new location, with such extensions in equipment and facilities as may be required. The initial plant will give employment to about 50 operatives, and this number, it is said, will be increased at an early date.

The United Engineering & Foundry Company, Farmers Bank Building, Pittsburgh, Pa., will take bids in the spring for the construction of a new plant building at Fifty-fourth street and the Allegheny Valley Railroad. The structure will be one-story, 50x150 feet, and is estimated to cost about $50,000. The company operates branch plants at Youngstown and Canton, O.

The Robesonia Iron Company, Lebanon, Pa., is arranging for a number of improvements and repairs at its local blast furnace. The unit was recently blown out, and during the idle period it will be relined and improved. A new hoist and other machinery will be installed at the plant. It is expected to start the work in the summer.

The Judson Manufacturing Company, San Francisco, Cal., expects to continue the improvement program at its plant during the present year, as in 1920. A new automatic stripper tower will be installed in the open-hearth department and other installations made for increased facilities. A new 30-ton open-hearth furnace was placed in service last year, making a total of three furnaces at the plant, with aggregate capacity of about 6,000 tons of material a month. The rolling fill department, improved and extended at the same time, now comprises a 16-inch bar mill, 19-inch bolt mill and two 10-inch mills.

The Sterling Steel Foundry Company, Braddock, Pa., has preliminary plans under way for the rebuilding of the portion of its plant destroyed by fire on January 27 with loss estimated at about $75,000. The plant has been giving employment to about 300 operatives.

The New England Iron Works, Dixwell aevnue, New Haven, Conn., has preliminary plans under way for the installation of new equipment at its plant for increased production. Extensions will be made to house the new machinery, which will consist of an electric traveling crane, steam hammer, shearing machinery and other equipment. The company specialize in iron and steel fabricating work.

The Peden Iron & Steel Company, Fort Worth, Tex., is planning for extensions and improvements in its plant at Main and Daggott streets, to form a complete new operating unit. The new building will consist of rolling mill, fabricating plant, metal and iron-working departments, machine shop, power house and other structures. Details of buildings and machinery installation are now being arranged. The project is estimated to cost about $1,000,000. D. B. Luce, Fort Worth, is engineer for the company.

The Hanna Furnace Company, Dover, O., will make extensive improvements at its blast furnace. It is planned to reline the furnace and build three new 22x100-foot stoves. Considerable new equipment will be installed in the power house, including five 2,000 horse power boilers, electric turbine and auxiliary operating apparatus. A new pumping plant will be constructed and a new warehouse.

The Indiana Rolling Mill Company, New Castle, Ind., is making a number of extensions at its plant for increased production. A new sheet mill is being completed, comprising a 28-inch mill and other equipment to provide a capacity of about 120 tons in 24 hours. An extension to the main building has been completed, and power house constructed, this latter building replacing a structure destroyed by fire early last year.

The National Tank & Steel Company, East St. Louis, Ill., is considering the erection of a new one-story addition to its plant for increased production. Details of the structure and proposed equipment are being arranged. It is estimated to cost about $50,000.

The New England Iron & Metal Company, Manchester, N. H., has plans under way for the erection of a new local plant for the manufacture of iron and steel products. The proposed structure will be 25x152 feet, and is estimated to cost about $60,000.

The Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., has plans under way for the erection of an addition to its plant at Westfield, near Birmingham, for the purpose of increasing present output. The structure will be used for the manufacture of steel products and is estimated to cost $300,000, including machinery.

L. P. Featherstone, Longview, Tex., and associates have organized a new company, to be known as the Texas-Louisiana Steel Corporation, with capital of $10,000,000. The new organization will take over the holdings of the Texas Steel Company and the Louisiana Steel Company. Property has been acquired about 40 miles north of Longview as a site for the erection of a new steel plant. A blast furnace of about 4505 tons capacity will be constructed, as well as a series of mill buildings for steel and iron production. Details of the project are being arranged, and it is proposed to inaugurate operations at an early date.

The Plants of the Weirton Steel Company

Description of the New Steel Plant, Including Blast Funace, Open Hearth Furnaces and Mills for Producing Sheet Bars, Billets and Slabs.

By C. H. HUNT,
Chief Engineer Weirton Steel Company.

THE plants of the Weirton Steel Company, Weirton, West Virginia, representing the development of an important independent steel company, are an interesting example of the evolution of a tinplate manufacturing company starting with a finishing plant only, broadening its operations by the addition of other lines of finished products to those which it set out to manufacture, and finally reinforcing its position by the addition of facilities for the manufacture and control of the materials entering into the various finished products from iron ore and other raw materials, until ready for delivery in their highly finished state.

The company then known as the Phillips Sheet & Tin Plate Co., had its beginning at Clarksburg, W. Va., in the starting of a six mill tinplate plant in July, 1905, four years later the company purchased a site on the West Virginia side of the Ohio river, four miles above Steubenville, O., along the Chester Branch of the Pennsylvania Lines and a short distance from its junction with the main line of the P. C. C. & St. L. Division, and commenced the erection of a 10-mill tinplate plant, marking the beginning of the present main plant and the town of Weirton, which now has a population of about 10,000 persons.

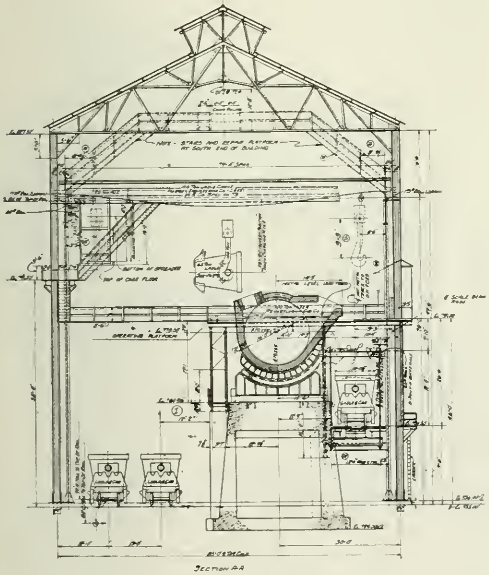


Fig. 1—Section Through Mixer Building.

The tin mill plant at Weirton was started in February, 1910, and has since been increased to a 26-mill plant by the addition of 10 mills the latter part of the same year and 6 more to the present time.

An important addition was secured to the company in January, 1912, by the purchase of the Pope Tin Plate Plant at Steubenville, O., consisting of 12 mills and 20 tin stacks, so that including the additions to the Clarksburg plant, the company is now operating 50 tin mills and 100 tin stacks, being the largest independent tin plate manufacturer in the country.

In June, 1915, the company purchased a cold rolled strip steel mill, which was started in Weirton in 1913 and then known as the Weirton Steel Company, consisting of 18 cold rolling mills and immediately commenced preparations for the addition of a 6 inch hot band mill with two 12 feet 0 inch by 45 feet 0 inch Laughlin continuous heating furnaces, 20 inch roughing, 16 inch duo strand and 16 inch finishing mills; also a 10 inch hot band mill, consisting of 11 foot 0 inch by 40 foot 0 inch Laughlin continuous heating furnace, a 6-stand 14 inch continuous roughing mill, 10 inch duo strand and 10 inch finishing mills, the former being placed in operation in December, 1916, and the latter in May, 1918.

This cold rolling department was likewise increased in the early part of 1917 by the addition of 22 cold mills, annealing, pickling, shearing, polishing, oiling and other finishing departments, so that the company now operates 40 cold rolling mills, finishing flat cold rolled steel in all forms from 16 inches wide down and in thickness down to .002 inch and hot rolled bands 1 inch to 16 inches wide of all thicknesses from No. 20 gauge and up on narrow sizes and No. 16 gauge and up on wide sizes.

Plans and calculations were started for the construction of a steel plant, as soon as conditions, which were then abnormal due to the war, would permit. The country was faced by an enormous shortage of pig iron needed for the production of war materials and munitions, the company decided to proceed with the construction of the present 600-ton blast furnace, which was blown in July 21, 1919, and has previously been described in the technical press, except for the changes which have been made to the boiler and power houses in connection with the building of the steel plant and in the method of handling hot metal from the furnace.

The steam generating and power plants for the operation of the blast furnace having been planned for case of extension to serve as the central power and pumping station for the entire projected developments, being located at the blast furnaces to secure the maximum advantage of steam and power generated from waste gases from the furnaces.

An analysis of the consumption of the finishing mills indicated that there would eventually be required steel making capacity for 65,000 to 70,000 tons of ingots per

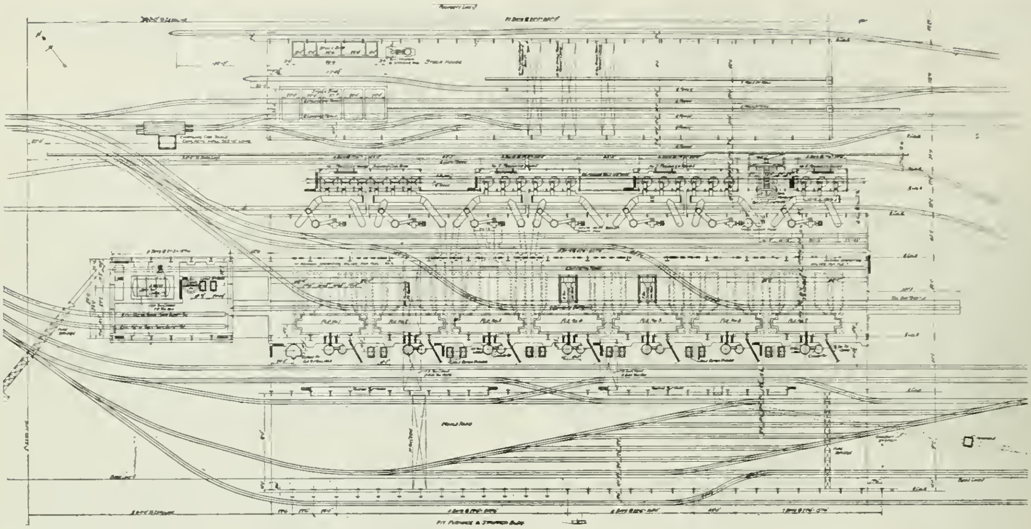


Fig. 2—General Plan of the Open Hearth Plant.

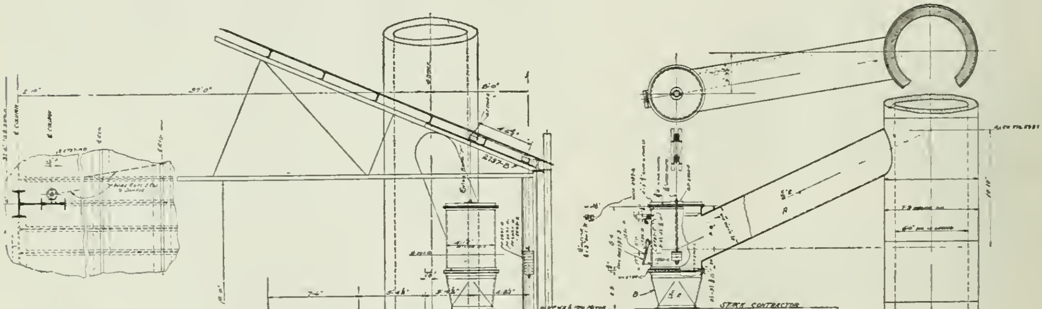


Fig. 3—Waste Heat Boiler Setting.

month and the entire steel plant and blast furnace layout was designed to meet these requirements, the open hearth plant being designed for the ultimate installation of fourteen 100-ton stationary furnaces, the present installation of seven furnaces comprising one-half of the intended plant.

The amount of scrap produced in open hearth practice is about 10 per cent, therefore the amount of metal necessary to supply seven furnaces would be about 38,000 tons per month, of this amount the present 600-ton blast furnace will produce not less than 17,000 tons of molten iron per month, leaving a balance of 21,000 tons of cold metal in the form of scrap of various kinds and some pig iron to complete the charge. The blast furnace, steel plant and finishing mills, will produce a total of 13,000 tons, leaving to be procured from outside sources about 8,000 tons per month.

On completion of the 14 furnaces, the hot metal and scrap requirements would be doubled so that the additional blast furnace would be required to supply hot metal and since the scrap production would be increased in about the same proportion, there would still have to be procured from outside sources about 16,000 tons per month and as this is more than equivalent to the production of a blast furnace, provision has been made for the future installation of a third furnace, should it prove of advantage to use hot metal instead of purchasing this scrap.

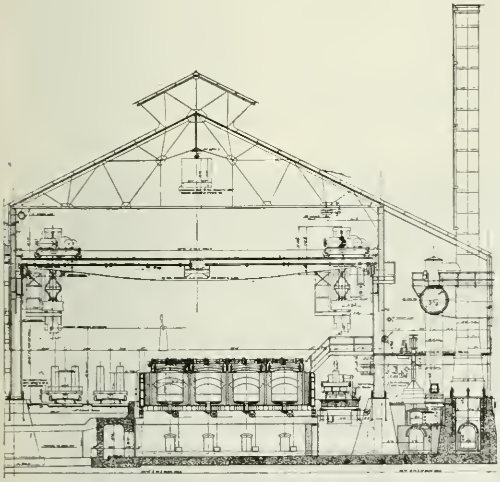


Fig. 4—Cross Section Through Pit Furnace Building.

The company has iron ore interests supplying a large quantity of the ore required for the present blast furnace, which amounts to approximately 400,000 tons per year. This ore is handled at present by discharging from the bottom of cars carried on overhanging brackets on the ore yard side of the stock bins and is handled to and from the stock piles by two 30-40 ton Brown locomotive cranes. For three furnaces there would be required 1,300,000 tons per year, which must be brought down from the mines during not to exceed seven months' navagation season on the Great Lakes, and unloading facilities must be provided at the furnaces to unload this ore and storage space for not less than six months' supply to cover the period during which navigation is closed. Therefore provision has been made for the future installation of a car dumper, movable the length of the storage yard, which will have a capacity for unloading thirty 280,000 pound cars per hour, including weight of cars, delivering their contents over the edge of the ore wall, and for ore bridges having a span of over 200 feet equipped with trolleys carrying 15-ton grab buckets for moving the ore back on to the storage piles, which can be 70 feet high and 1200 feet long between the car dumper wall and the furnace stock bins, and also reclaim the ore from the stock piles and deliver it to a larry car or direct to the furnace stock bins.

The company at present has through its interest in the Redstone Coal and Coke Company, in the Connellsville region, a sufficient supply of beehive coke for the requirements of the present blast furnace.

To provide for the future, upon the completion of additional blast furnaces, since each blast furnace requires from 180,000 to 200,000 tons of coke per year which is equivalent to the production of one battery of by-product coke ovens, provision has been made for the future installation of three batteries of ovens with complete by-product plant, which will be located on the river bank paralleling the Weirton tin mills, with arrangements for receiving coal by river and unloading it from barges and delivering it to the crushing and pulverizing plant on the bank 88 feet above the river.

A storage space has been provided for 130,000 tons as assurance against low or frozen river and other contingencies.

Provision has been made for a complete by-product plant for reclaiming tar, light oil, ammonium sulphate, benzol, toluol and solvent naphtha from the gas distilled from the coal in the ovens. The supply of gas not required for heating the ovens will be available for use in the furnaces at Weirton tin mill and for heating furnaces at the steel plant.

It is contemplated that the coke when pushed from the ovens and quenched will be delivered to a conveyor belt and elevated to a screening tower, flowing from the screens into a specially built electric driven car, to operate on a high trestle track and to connect with the track over the storage bins at the blast furnace, delivering the coke direct to the bins at the furnace skips.

The company also owns a large tract of coal land which is suitable for supplying the various needs of fuel at the plant and therefore have provisions for practically all raw materials and facilities for the complete control of the quality of steel entering into the various finished products of the company.

The accompanying general layout map shows the relation of the various units of the plant to each other and to the Weirton Tin Plate Plant and Strip Steel Plant, also indicating in dotted lines the provisions for extensions to the departments of the steel plant and blast furnace and the location of the future by-product coke plant.

In view of the peculiar shape of the property available and its location on the opposite side of the Pennsylvania Railroad from the existing plants, a problem, which has been successfully worked out, was presented in the efficient grouping of the units of the plant to secure the most economical arrangement of transportation facilities for delivery of raw materials to each department as required, for the shortest and most direct inter-department movement of materials during process of manufacture, and the delivery of sheet bar, slabs and billets to the finishing mills or to the railroad, and to so lay out these tracks that they would be adaptable to all future uses and extensions with the least change or interference with operations, particularly since standard gauge track and rolling stock have been used throughout the plants.

Due to the lack of railroad facilities at the present time in the vicinity for the storage and classification of inbound freight and outbound materials or empties, the further necessity was imposed for the construction of a storage and classification yard of sufficient size to serve the requirements of the plant, this yard having a capacity of 400 cars.

A further condition of which advantage was taken in the arrangement of the plant, was the gradual sloping of the site from the east side along Second street down to the railroad line on the west side and since the elevation of the general yard level was practically determined by the elevation of the railroad line, in order to secure an easy gradient of approach from the railroad. It was necessary to remove over 140,000 cubic yards of earth to bring the plant site to the proper level, and by locating the open hearth stockyard on the high ground parallel to Second street, to save a great amount of excavation and to maintain the charging tracks in the stockhouse on the same level as the open hearth charging floor, a very great advantage in the transportation of the trains of charging cars from the stockhouse to the open hearth, particularly in wet or snowy weather by eliminating the usual long graded fill or trestle approach with its consequent delay and added cost of motive effort.

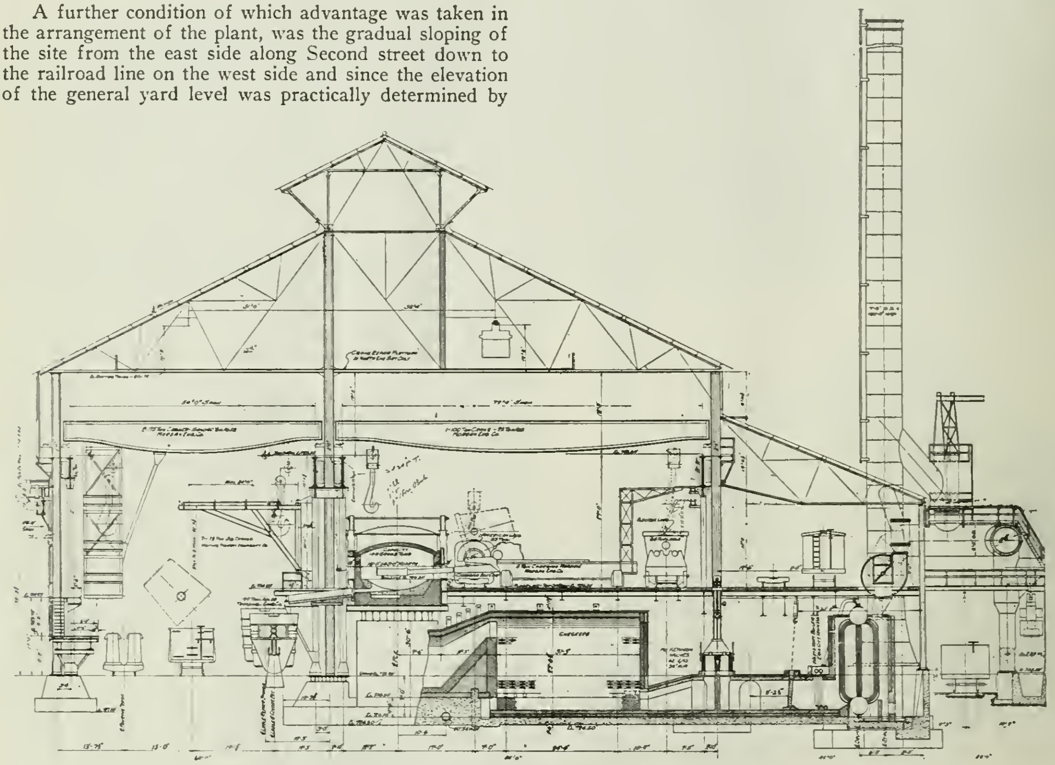


Fig. 5—Cross Section Through Open Hearth Building.

The arrangement, which is clearly shown in the accompanying cross section and plan of the open hearth plant, permitted the parallel arrangement of the gas producer houses and stockyard back of the open hearth charging bay and the consequent ease of extension of these buildings in accordance with the extensions to the open hearth building, it being the intention on completion of the plant to its ultimate length to also provide a connection at the south end from the stockhouse to the open hearth charging floor for ease and avoidance of congestion in bringing cold stock to the furnaces at this end of the plant.

All inbound materials enter the plant at the southwestern entrance and are delivered to the storage yard or go direct to the point of consumption; ore, limestone and for the present coke, are taken from the yard over a graded approach track to the high level tracks over the stock bins at the blast furnace, coke and limestone being unloaded direct from the cars into their respective pockets and the ore during the season of its movement, either direct to the ore pockets or to the unloading track for movement to the storage piles, and upon completion of the future ore handling equipment, will go forward from the yards to the car dumper, all outgoing empties being returned to the railroad from this end of the yard to avoid interference with incoming material.

The movement of scrap to the stockhouse and coal to the gas producers of the stock plant, is from the southern end of the yard as can be seen by reference to the general layout and arranged to permit the free movement at all times of steel outbound from the mills.

Hot metal will move from the pouring tracks between the furnaces and boiler house to the mixer at the north end of the open hearth building, while casts not required at the open hearth plant may be poured direct from ladles on cars into the Pittsburgh coal washer pig machine located at the end of the cast house of the present furnace, where prior to the completion of the steel plant it was arranged for running metal direct to the pig machine, while the plant was operating as a merchant furnace. The temporary iron runners and ladle stands having been removed and replaced with runners to three spouts at the side of the cast house to pour into 65-ton Pollack ladles and cars. Pollock short pour ladle stands are placed at the pig machine to suit the ladles on cars, which are poured by the Whiting crane in the present cast house.

The entire steel plant was designed and built under the direction of C. H. Hunt, Chief Engineer of the company, under its operating head, J. C. Williams, vice president and general manager in charge of operations, the engineering organization of the company having prepared all plans, specifications and details for the steel plant and the general layout of the entire plant, including the blast furnace and provisions for the future coke plant.

All excavations, foundations, fill, brickwork and installation of the machinery and equipment was done by the company under the supervision of the Jack Walsh Construction Company. All structural steel work for the building was furnished and erected by the McClintic-Marshall Construction Company.

An unusual record was established in the building of a plant of this magnitude, particularly in view of the difficult circumstances affecting the manufacture and delivery of equipment during the period of construction occasioned by the coal strike, switchmen's strike and the steel strike and the extreme rigor of the winter of 1919 and 1920, as foundation work for the plant was started on June 15, 1919, the first heat of steel was poured at the open hearth November 22, 1920, and the first three ingots drawn rolled all the way through the mills as commercial sheet bar November 29, 1920. Therefore in spite of the difficulties encountered, the plant was completed and in operation within 17 months of commencement of construction.

Hot metal is brought from the blast furnace to the mixer building in 65-ton Pollock ladle cars drawn by an 80-ton American yard locomotive and is weighed on a 200-ton railroad track scale, furnished by the Strait Scale Company, located just north of the mixer building.

It was decided instead of installing a mixer of small capacity for the present plant and later adding an additional mixer, to serve the requirements of the additional furnaces, to install at the beginning a mixer of sufficient size for the ultimate requirements, and this mixer of 1300 tons capacity and at present lined down to 1000 tons, is of the cylindrical type and was furnished by the Pennsylvania Engineering Company. It is housed in a separate building at the north end of the open hearth and separated therefrom by an intervening space of 22 feet 6 inches, being 127 feet 6 inches long by 85 feet center to center of columns and 92 feet high from yard level to the underside of the roof chords.

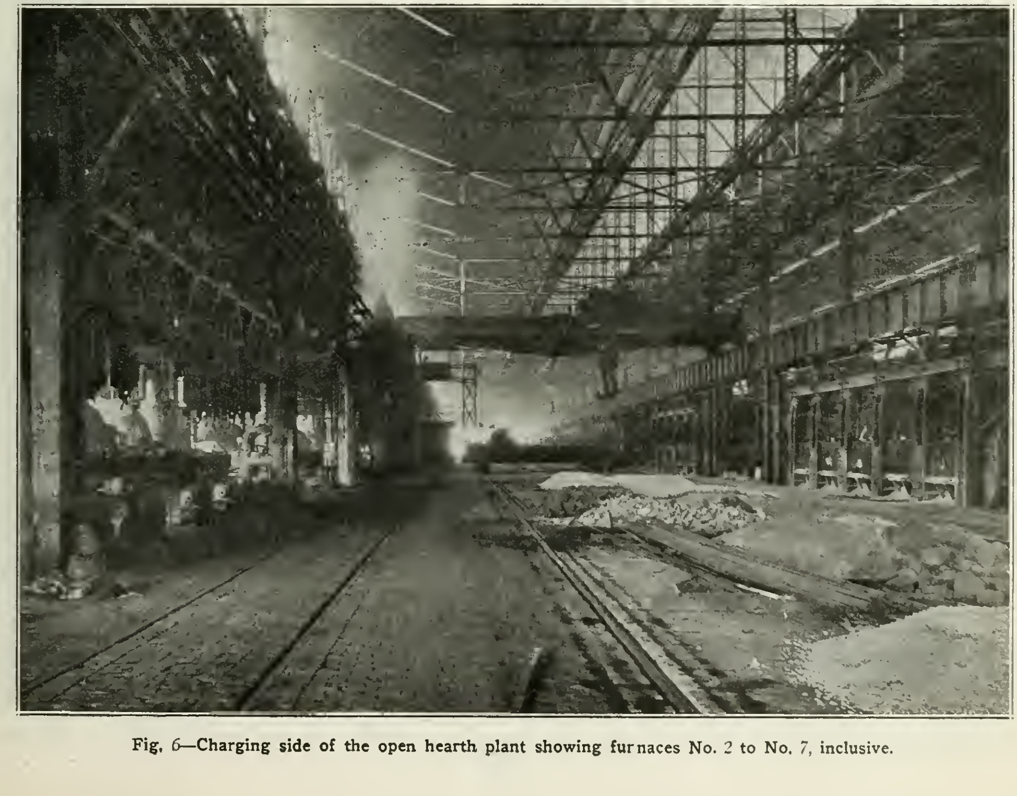


Fig. 6—Charging side of the open hearth plant showing furnaces No. 2 to No. 7, inclusive.

The mixer is electrically operated by two 87½ hp motors, connected in series, and either motor is of sufficient capacity to operate the mixer in case of trouble with the other. The receiving spout cover is operated by hoisting mechanism driven by a 7½ hp motor. The control masters for all motors and the magnetic panel for the main motors are located on the operating floor and totally enclosed in a brick structure to protect all parts from the accumulation of dirt.

The center line of the mixer is 43 feet above yard level, the metal being lifted and poured into the receiving spout by a 10-ton Morgan crane, equipped with 25-ton auxiliary, the crane having a span of 79 feet 4 inches and the height of the crane runway from yard level being 76 feet.

The delivery side of the mixer is on a line with the charging side of the open hearth building and is at the same elevation or 19 feet 6 inches above yard level. From the mixer the metal is poured into 65-ton ladles of the same design as those used in bringing metal from the blast furnace to the mixer. The ladle car stands on a weighing scale platform while being filled, the metal being weighed also as it leaves the mixer, the weigh platform is connected by four suspension rods to the scale beams, which are installed overhead and just under the operating platform to avoid damage in case of a spill of hot metal from the mixer while pouring, the weigh beam being located in the same house with the control. This scale is of 150-tons capacity and was furnished by the Fairbanks Company.

The operator when pouring is located in one end of the control house with the scale beam at his side and has a clear view of the mixer and the ladle through a novel arrangement of windows in the control house and grating in the operating floor.

Ample escape platforms and runways have been provided for the mixer operators and cranemen, escape runways also being provided on the outside of the building at the levels of the crane cage and pouring floor with revolving doors conveniently spaced in the sides of the building to allow the men to get outside in case of a serious spill within the building.

A Baldwin-Westinghouse electric locomotive hauls the hot metal ladle cars to the open hearth plant on a standard gauge track located back of the charging machine tracks on the open hearth floor.

The open hearth department comprises seven of the 14 eventual furnaces, housed in a building 190 feet wide by 637 feet 6 inches long with a height from yard level to bottom chord of roof trusses of 66 feet 9 inches. The width is made up of three aisles, the pit on the pouring side of the furnace is 60 feet wide, the charging bay proper is 85 feet wide and is supplemented by a leanto on the gas producer side 45 feet wide, containing a continuation of the charging floor which is 19 feet 6 inches above yard level.

The furnaces are constructed to nominal 100-ton lines but have sufficient hearth area, being 16 feet wide by 40 feet long to melt 120 tons at a heat, for which ladle capacity has been provided, in fact to test the capacity of the furnaces, a 130-ton heat has already been successfully poured and due to this tremendous melting capacity, the furnaces are of very heavy construction throughout, bound with cast steel water cooled buckstays. The furnace bottom is built up from a ¾-inch steel plate pan, resting on a transverse grillage of 15-inch I beams, supported on 12 24-inch 100-pound I beams, placed longitudinally and resting on two massive concrete piers supporting the

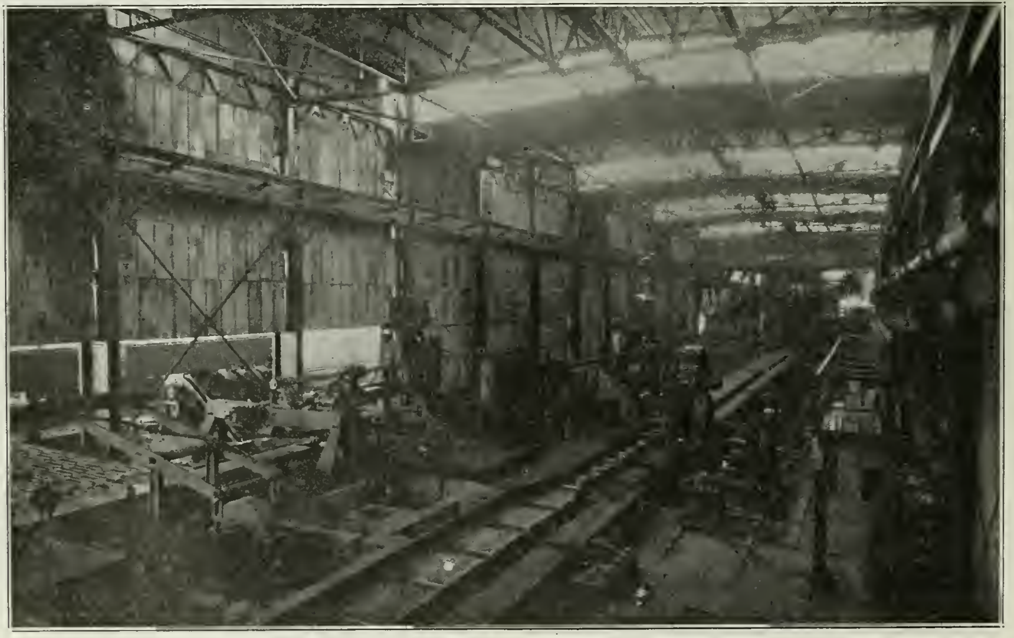


Fig. 7—600-ton steam hydraulic shear and shear table and gauge and 300-ton cropshear looking toward the blooming mill.

furnace, the ends of these beams being extended as a cantilever over the top of the air slag pocket to support the wind box.

The gas and air regenerators, located back of the furnaces, are built separate 31 feet 3 inches long inside, 20 feet 6 inches high from bottom of flue to top of arch and are respectively 8 feet 4 inches and 12 feet 6 inches inside. The checker work in the chambers is of standard type made of 9x4½x2½ inches first quality fire brick.

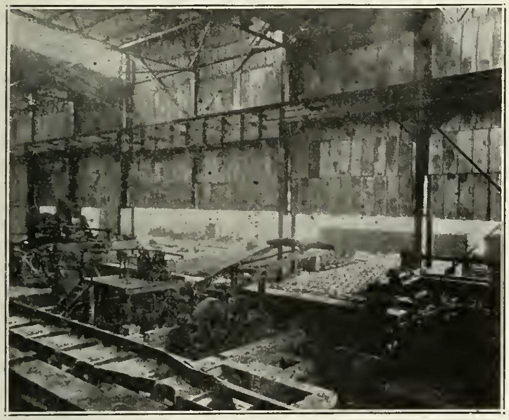


Fig. 7—Slab and billet conveyors showing pushers and operating platform with 600-ton billet shear at the left.

On account of the gravelly formation of the valley in which the plant is located, the ground around the furnaces frequently becomes saturated with water coming down from the hillside, therefore the slag pockets, regenerators, flues and waste heat boiler settings which are provided at each furnace, are built on a concrete pad, the sides of which enclosing the entire area under the charging floor are carried up above yard level, forming a water tight concrete pan. All brickwork resting directly on top of the concrete, which has a slight slope toward the pouring aisle side, rests upon a red brick subbase, constructed to form drain ducts in the direction of the slope, and any water seeping through is thereby discharged into a drain trench without injury to the brickwork, the weight of the binding for the regenerator chambers, slag pockets and the boiler settings also being supported on the concrete pad.

The furnaces are provided with five charging doors and frames of the Knox water cooled type, the three center openings being 36 inches high and 48 inches wide with doors 3 feet 4 inches and 4 feet 8 inches wide, the end openings being 36x36 inches, with doors 3 feet 2 inches by 3 feet 8 inches wide. The doors are operated by motor driven worm gear hoists, furnished by the Pennsylvania Engineering Works. two of the furnaces are provided with Knox water cooled ports, two are equipped with Blair water cooled semi-circular ports with water cooled bulkheads and the remaining three are of the usual dry port construction, equipped with pipe coolers. The gas and reversing valves on furnaces 1 to 6 inclusive are of the McKennon water cooled and water sealed type, the gas inlet and reversing valves at 42-inches and the air reversing valve 54 inches, there being six to each furnace; furnace No. 7 is equipped complete with Knox water cooled damper type valves. All valves are motor operated, no hydraulic power being used in the open hearth department, avoiding trouble with frozen lines, therefore a special type of drive was developed by the company for the operation of the McKennon valves, the motor drives of this equipment being located between the mail building columns back of the charging floor and are equipped with a special hand adjustable electric cutout arrangement, governing the amount of opening to the valves which allows the melter to regulate from the charging floor, the differential temperatures of the gas and air chambers.

A novel arrangement of control has been installed for operating the valves and doors, the controllers being placed over head on girders spanning between the main building column, allowing free passage way underneath, the control for two furnaces being grouped together, the valve control for one furnace being at one end and for the other furnace at the opposite end, with the door control for the two furnaces located at the center of the girder. The steam control valves to the gas producers and the draft control on the open hearth boilers are also located here, so that it is all convenient to the melter, without crossing tracks in the leanto congested with stock trains.

A waste heat boiler is installed at each furnace for utilizing the heat in the waste gases from the furnace. Steam is developed at 225-pound pressure, some of which is used in the gas producer plant for blowing the producers, and the remainder delivered to the main steam line, which passes down through the open hearth building along the main columns back of the charging floor, connecting the boiler plate at the blast furnace with the engine at the blooming mill, so that this steam can be utilized either at the blooming mill or at the power house in case the mill is down.

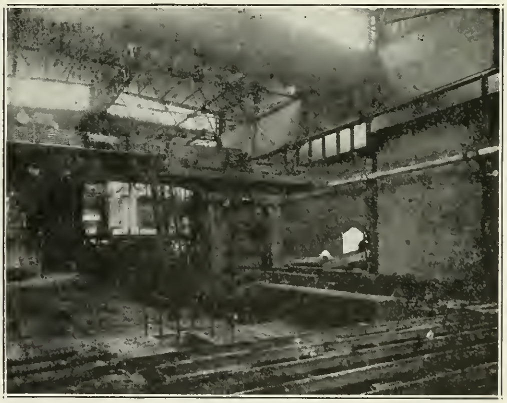


Fig. 8—40" blooming mill showing Mesta universal spindles connecting with the pinion housing.

The boilers are of the vertical water tube type of 600 hp rating, built by the Erie City Iron Works. The boilers are located on the center line of the furnace underneath the leanto floor as close as possible to the valve in order to avoid the loss of heat. A by-pass flue is provided to a bell bottom stack 6 feet inside diameter by 160 feet high, furnished by R. Munroe and Sons, Pittsburgh, each flue being provided with a chain block operated Knox water cooled valve with water cooled seat for sealing off direct flow of gases to the stacks. A chain block operated dry hammer is also installed in the flue leading to the boilers. Foster super-heaters, furnished by the Power Specialty Company of New York are installed vertically in the flue at the entrance to the boiler, designed to super-heat the steam to 125 degrees, corresponding to the super-heat carried at the power house and throughout the steam system. The boilers are also equipped with Diamond Power Specialty Company soot blowers for cleaning the boilers and two elements are installed in connection with each set of superheater tubes.

Mechanical draft for the boilers is provided by a specially designed motor driven fan, mounted on the extension of the charging floor in the leanto bay, directly above the boiler breeching; a connection from the fan in which is installed a valve for sealing off the boiler when not in use, delivers the gases into the furnace stacks. The fans were furnished by the B. F. Sturtevant Company and are driven by 100 hp constant speed ac motors. They are of full housing, double inlet type, specially designed to prevent the collection of soot to destroy their balance and provided with a through shaft carried in water cooled bearings on each side of the fan. A special air cooled shield surrounds the shaft on the inside to prevent unbalance due to warping of the shaft. As an additional precaution against vibration, the section of the floor immediately surrounding the base of the fan was filled in solid with concrete. The fans are designed to give a maximum static pressure of 5 inches when delivering 120,000 pounds of gas per hour. A damper is located in the outlet from the boiler, connected to an operating stand on the main column back of the charging floor at the control station, where the draft on the furnace may be regulated. The boilers are fitted with Copes feed water regulators, the treated water after being heated in the main heating plant at the blast furnace boiler house, is delivered at low head through an insulated line to a point central to the final open hearth layout and delivered into a tank on the charging floor level, from which one of two 4-inch Jeanesville centrifugal boiler pumps deliver the water to the boilers. These pumps are driven by 125 hp Moore steam turbines, the exhaust from the turbines being introduced into the tank which receives the treated water, making up for any loss of heat coming through the supply lines from the heating plan at the boiler house and imparting additional heat to the water.

For charging the open hearth furnaces with scrap, ore and other materials, there are two 5-ton low type Morgan charging machines with a span of 24 feet 6 inches for handling the charging boxes, which are run in from the stock house on a standard gauge track in front of the furnace doors. Hot metal is brought in from the mixer building on a ladle car over a standard gauge track, between the charging machine track and the main building column to a point opposite the furnace and is lifted by a 100-ton Morgan ladle crane, having a span of 79 feet 4 inches and provided with a 25-ton auxiliary trolley for pouring.

Two tracks traverse the leanto and afford storage for stock trains ready to be charged. Crossovers are provided for every three furnaces with the charging car track in front of the furnaces. Connection is made with the high level tracks in the stock house at the north end of the building by a steel bridge and on completion of the 14 furnace layout, a like connection will be provided at the south end of the plant,

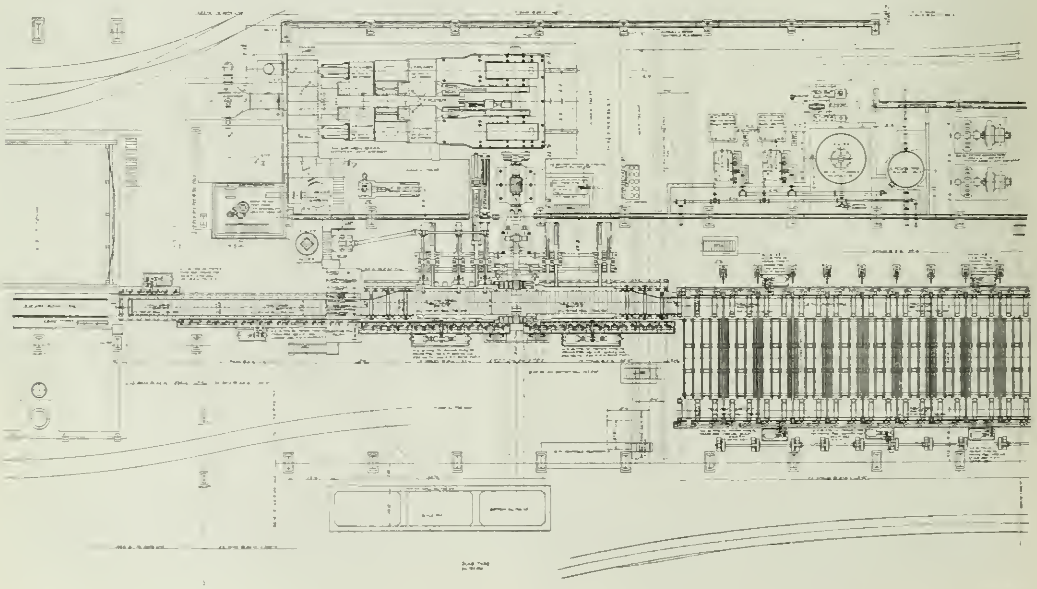


Fig. 9—General layout of

with crossovers arranged in the opposite direction.

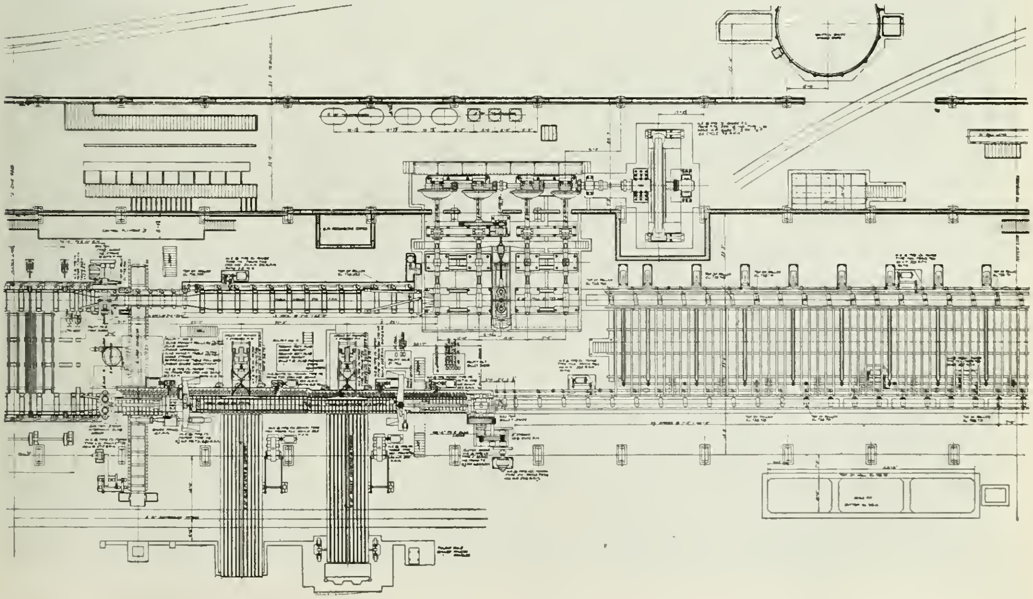
The pouring floor is traversed by two tracks; the track nearest the furnaces is a through service track used for handling cinder, skulls, refuse, etc.—the track near the outside column is used for spotting the ingot moulds for pouring the steel. Two pouring platforms are provided alongside the building columns adjacent to this track and crossovers are provided between the pouring platforms so that the ingot trains may be drawn out from either end as provision has been made for spotting ingot moulds for two heats at each platform. Two 175-ton Morgan ladle cranes, each having a 40-ton auxiliary trolley, equipped with a 15-ton auxiliary hoist, are provided for handling the 120-ton ladles on the pouring side. Cinder pots of 260 cubic foot capacity are mounted on stands alongside the ladles when in pouring position to receive the overflow of cinder from the ladles.

The steel ladles, cinder pots and cinder cars were furnished by the M. H. Treadwell Company. The ingot moulds are mounted for pouring in a double row on cars designed for carrying six moulds and furnished by the Wheeling Mould and Foundry Company. These cars are equipped with Hyatt Roller Bearings. A 7½-ton jib crane, made by the Whiting Foundry and Equipment Company is attached to the building column at each furnace for handling the pouring spout. Over both the charging floor crane and pit cranes for repair purposes, there is a 7½-ton monorail trolley, furnished by the Toledo Bridge and Crane Company, louped at the end of the building so as to serve the cranes in either aisle.

Ample platforms and walkways surround the crane runways accessible by stairways leading up from the charging floor and an escape platform is provided for the ladle crane operator on the pit side directly above the pouring platforms and extending the entire length of the building to allow the operators to escape with safety in case of a bad spill.

Producer gas is the fuel used in the open hearth furnaces and the gas plant consists of 21 Morgan mechanical producers equipped with automatic measuring feed and self-cleaning ash pans. The producers are arranged in batteries of six, three for each furnace, each battery being housed independently in a steel building 105 feet long, 22 feet wide, center to center of columns. The operating floor of the producer houses is on the same level as the open hearth charging floor and the stock house, and at each battery house are provided foot bridges connecting with the open hearth charging floor and the stock house. The connection from the gas producers to the furnace flues is by means of overhead gas mains, three producers being separately connected to each furnace. An overhead burnout connection is installed between each main and the furnace stacks—the gas mains are insulated with a 2½-inch lining of Sil-O-Cel brick between the steel plate and the 4½-inch fire brick lining to prevent loss of sensible heat in the gas due to radiation, the diameter of the mains being 5 feet 8 inches inside of brickwork.

Opposite each producer ample dust legs are provided which extend down to the foundation also serving as supports for the mains. The connection of the goose neck from the producer into the dust leg is so arranged that the gas is deflected downward before rising up into the main, the reversal of direction throwing down into the dust leg the greater part of the soot and dirt which comes over with the gas and has proven of material benefit in keeping the mains and flues free from these deposits. Steel walkways have been provided along the top of the mains with ample platforms and stairways for access to



upper end of the mill.

burnout connections, doors and lance holes. The entire system of gas mains and walkways was furnished and erected by the William B. Pollock Company.

The coal handling system was furnished by the C. O. Bartlett & Snow Company and is located at the center of the ultimate line of producer houses. Coal is received on a track between the producers and the stock house retaining wall and is run from the bottom of the cars into a track hopper, located underneath this track at the coal hoist, from the track hopper the coal is conveyed by a 26-foot wide apron type conveyor, having a capacity of 150 tons per hour, operating at a speed of 30 feet per minute, to a 24x24-inch two roll crusher, which delivers it into a hopper discharging into two skip buckets of 120 cubic feet capacity, which automatically elevate the coal into a 500-ton overhead storage bin.

Gates are provided in the chutes leading from the hopper to the skip bucket, arranged in such a manner that they are automatically closed at all times except when the skip bucket is in a position to receive coal. As soon as the skip becomes loaded to the proper level, it settles by weight onto an arm which automatically starts the hoist, one bucket being lowered into position as the other is elevated. Screens are provided at the top of the hoist for screening out fine slack coal which is discharged into a central pocket of the storage bin from where it may be returned to a car on the receiving track and sent to the boiler house, by this arrangement only coal of a suitable size need be charged into the producers.

A chute is also provided for coaling the locomotives which handle the stock on the charging floor level between the stock house and the open hearth. From the storage bin coal is drawn through air operated valves in the bottom of the bins, of which there are five, into a 10-ton center bottom dump electric transfer car, equipped with scales for weighing the coal, furnished by the Atlas Car and Manufacturing Company. The transfer car travels the length of the producer plant, bridges spanning the intervening space between the producer houses, and discharges the coal into individual hoppers over each producer having a capacity of 38 tons, out of the bottom of which the coal flows as required to the automatic feed of the producers.

On the furnace side of the gas houses located between the building column piers and the piers for the dust legs, is a concrete trench extending the length of the gas house into which the ashes are automatically blowed from the ash pan to the producer. The dust which collects in the dust legs is discharged through a bottom bell valve, operated from the producer floor into the same trench, mixing with the ashes. A monorail bucket trolley furnished by the

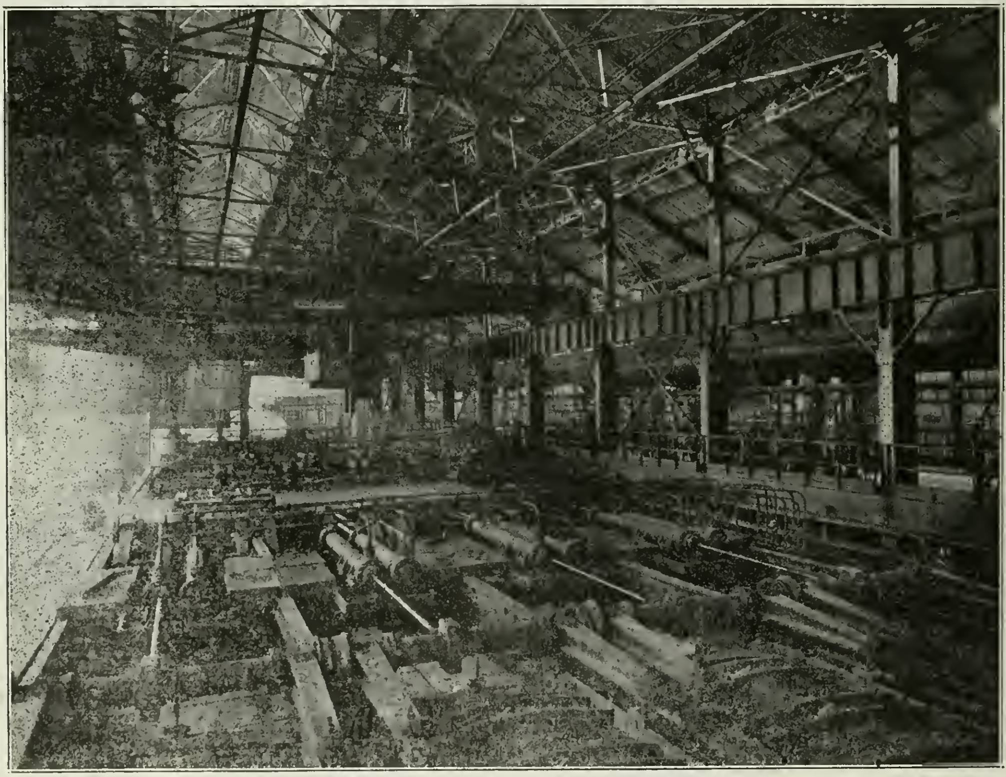


Fig 10—Five of the six soaking pit furnaces with regulating and receiving valve platform at the right, showing blooming mill in the background.

Toledo Bridge and Crane Company, carrying a 1¼ cubic yard Hayward bucket, travels on an I beam track over the ash trench, removing the ashes from the trench, loading them into a standard railroad car on the track between the producer house and the furnace building, the monorail curving out over the track at a point opposite the coal hoist. This novel arrangement for handling the ashes, together with the system for handling the coal and the automatic feed on the producers, reduces the labor required in this department to an absolute minimum.

The raw materials for charging the furnaces are brought from the stock yard, located in a covered steel building 600 feet long by 103 feet 6 inches span center to center of columns, having a span center to center of crane runway rails of 100 feet. At the north end of the stock house are located reinforced concrete bins for the storage of limestone, iron ore, dolomite, fluerspar, etc., which are built below the level of the stock house, permitting the unloading track to be carried over the top of the bins so that the material which spills over when being dumped from the bucket falls back into the bin avoiding any labor in cleaning up. At this end of the building opposite the main storage bins are installed above floor level, concrete bins for the storage of chrome ore, magnesite bins, dolomite, ferro-manganese, etc., at one end of which is located the crushing and grinding plant, consisting of an 8-foot wet grinding pan and a 10x16-inch Buchanan crusher.

There are two levels extending the length of the stock house, the higher level being on the same elevation as the charging floor of the open hearth and traversed by two tracks inside the building on which the stock trains are loaded and a runaround track outside the building between the retaining wall on the gas producer side and the building columns. These tracks are elevated 5 feet 5 inches above the general level of the stock house, so that the top of the charging boxes on cars is about the same elevation as the top of gondola cars standing on the lower level, this construction being adopted to facilitate the unloading of scrap direct from cars into charging boxes and avoid excessive hoisting and lowering of the magnet.

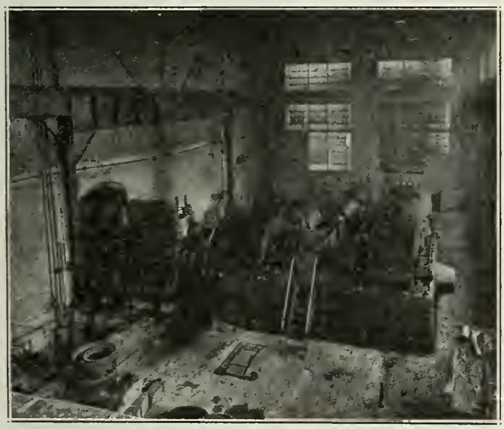


Fig. 11—View showing 42x66x60′ horizontal turn tandem compound reversing engine and blooming mill pinion housing.

Two tracks traverse the stock house on the lower level for handling material coming in on standard railroad equipment. A retaining wall separates the two yard levels and a wall 4 feet high is built alongside the tracks on the lower level to increase the storage capacity which is provided between these tracks and the cast side of the building, there being ample storage space provided under the cranes for 40,000 tons of pig iron.

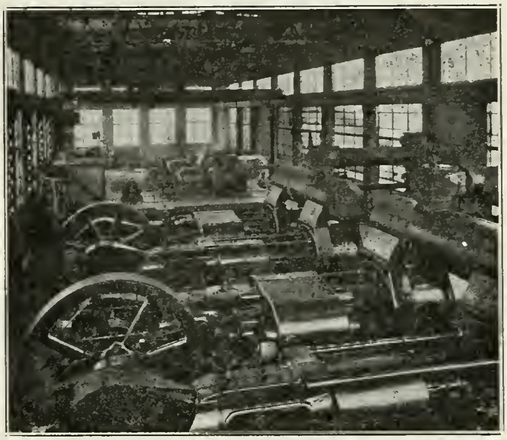


Fig. 12—Showing three 7,500 kw turbine driven generators. Blast furnace blowing engines are shown in the foreground.

The building is served by two 10-ton cranes equipped with single hoists for handling 62-inch Cutler-Hammer magnets and one crane is equipped with a 10-ton magnet trolley and a 10-ton bucket trolley mounted on the same bridge equipped with a 2-cubic yard Blaw-Knox Bulldog type bucket. These cranes were built by the Champion Engineering Company, Kenton, Ohio.

The cinder yard is located about 600 feet south of the eventual end of the open hearth plant and is an open runway 320 feet long by 80 feet wide, center to center of column and is served by a double trolley Champion crane, having a span of 76 feet 6 inches. One trolley is arranged for handling a 3-cubic yard Blaw-Knox Bulldog type bucket and the other trolley is equipped with a 25-ton hoist and a 10-ton auxiliary for handling a 10-ton magnet. The crane runway rail is 44 feet above level and provision has been made to erect in the future over one-half of the length, a runway which will be 67 feet above yard level, to be utilized as a high drop for breaking skulls, scrap, etc. At present the 5½-ton drop ball is handled by the 62-foot Cutler-Hammer magnet.

The pit furnace and rolling mill department is west and parallel with the open hearth building, being separated by a space of 105 feet from center line of open hearth building columns to center line of pit furnace building columns. Crane runways are provided on the outside of each building, and the yard, which is used for mould storage, the cooling and storage of ingot trains, is covered by a 10-ton Champion crane having a span of 99 feet 9 inches for handling moulds and making up trains. The ingots coming from the open hearth are weighed on a 20-ton Strait platform track scale located north of the end of the stripper building.

Six pit furnaces are housed in a building 89 feet wide, center to center of main columns, by 450 feet long, with a 26 foot wide leanto on the west side 292 feet 6 inches long over the valves and operating platform. The crane equipment consists of one 150-ton Morgan screw type stripper and two 7½-ton Morgan soaking pit crane, with 10-ton auxiliary hoists for handling coke buckets, etc., the span of the cranes is 85 feet. A 7½-ton monorail trolley, duplicate of the trolley in the open hearth building, is installed in the roof trusses for repair work on the cranes.

The pit furnaces are all of the four hole regenerative type, each hole 6 feet 3 inches by 8 feet, having a capacity of six ingots; the top of the pits is 7 feet 6 inches above yard level,

Producer gas is the fuel used, each pit being equipped with separate hand regulated water cooled mushroom valves for adjusting the air and gas supply and the reversal of the entire furnace being accomplished by six 36-foot McKennon valves operated by hydraulic cylinders, this equipment was furnished by the Pennsylvania Engineering Company.

The pit furnace covers are mechanically operated and were especially designed to prevent water due to leaks in packing or gaskets from coming in contact with the furnace brickwork and also constructed to minimize warping or burning out due to heat from the pits, and damage to the brickwork around the top of the pit when closing. They were furnished by the Connellsville Foundry, Machine and Steel Casting Company.

Six Morgan mechanical gas producers, duplicates of those installed at the open hearth plant, furnish gas for the pit furnaces. The gas main connecting the producers to the furnaces are insulated with a 2½-inch lining of Sil-O-Cel brick between the shell and the 4½-inch fire brick lining, the main header 6 feet 8 inches inside diameter, of brickwork, is connected at each end of the producer house with a 5 foot 9 inch inside diameter distributing main, supported above the valve operating platform with 3 feet inside diameter downtakes to each furnace. The pit furnace stacks are 4 feet 6 inches inside diameter of brickwork and 95 feet high. A burnout connection is provided at No. 1 and No. 4 furnaces between the gas main and the stacks, as at the open hearth the gas mains are provided full length with ample steel walkways for safe, convenient access to all burnout doors and lance holes. The piping was furnished and erected by the William B. Pollock Company and the six pit furnace stacks by R. Munroe & Sons Manufacturing Corporation.

The coal and ash handling equipment was furnished by the Link-Belt Company, coal being supplied to a yard level track hopper located at the side of the producer house at one end, from which it is delivered by a 24-foot wide steel apron conveyor, having a capacity of 70 tons per hour to a 28-foot diameter by 24-inch two roll crusher, discharging into a Peck overlapping pivoted bucket type conveyor, which elevates the coal passing over the top of the 60-ton individual coal bunkers over each producer, arranged with a tripper for discharging coal into any one bunker as required.

The 18-inch 6-strand continuous sheet bar mill is designed to produce sheet bar 8 inches wide of any weight from 6-2/3 pounds to 46 pounds per foot and is designed to permit of rolling flats up to 15 inches wide. This mill can also be changed over to roll 1¾-inch squares and larger and will roll its range of billets from a 4x4-inch square section, its product of sheet bar from an 8x2-inch slab as delivered from the 21-inch mill, and has a capacity of 60,000 tons per month of 10-pound sheet bar, or 1¾-inch billets.

The mill buildings are of steel and brick construction with high and low bay type roof over the main aisle and including the engine house and motor house, are covered with a cast-in-place monolethic gypsum slab roof furnished and applied by the H. H. Robertson Company, the roof and sides of the slab yard down to a height of 18 feet above yard level, being covered with corrugated steel.

The crane equipment was all furnished by the Champion Engineering Company, the blooming and continuous mill building is served by a 30-ton crane with 15-ton auxiliary hoist and a 15-ton crane, the span of both being 66 feet. The engine house is covered by a 45-ton crane with 15-ton auxiliary, having a span of 50 feet 10¼ inches, while over the sub-station and motor house leanto, a 15-ton crane, span 28 feet 7 inches, is used for general repair work and for handling rolls to the roll lathes, which are located in this department. For handling slabs and billets in the slab yard, a 15-ton crane, 85-foot span, is provided for handling either magnet, chains or special lifting cradle for handling piles of slabs and billets from the conveyor. The sheet bar yard is served by a 15-ton double drum trolley crane, 85-foot span, equipped with a special lifting beam for sheet bar piles.

The blooming mill, manipulator, tables, shears, crop conveyor, pusher and equipment up to the 21-inch mill and up to and including the billet shears, was all furnished by the Mesta Machine Company, with the exception of the slab and billet conveyors, which were built by the Treadwell Engineering Company. The continuous mills and drives, skew connecting table, broadside transfer and billet shear table, Edwards flying shear, piling rolls, bar piler and the combination sheet bar and billet hot bed were furnished by the Morgan Construction Company.

The blooming mill is a two-high reversing mill, with rolls 36 inches diameter by 92 inches long. The screwdown mechanism is of special construction, bevel gear driven, totally enclosed in dust tight cases, designed to allow ease of removal for renewal of wearing parts and is operated by two 100 hp motors, connected in series. A Kennedy pinion housing with broad base is bolted direct to the foundation and contains two 40-inch pitch diameter pinions, 50-inch face with 16 double helical planned teeth. The mill spindles are steel forgings 16 inches diameter by 18 feet long, provided at both the roll and pinion ends with Mesta Universal couplings. The top mill roll and spindle are hydraulically balanced by constant pressure furnished by an independent accumulator and with special hydraulic pullback arrangement provided on both the top and bottom spindles for ease in changing mill rolls, the spindles being manipulated without the use of blocking or the crane, leaving the crane free for handling the rolls. The mill is connected to the engine by means of a Kennedy link type Universal coupling so that the drive from engine to mill rolls is free from back lash, eliminating wear and tear on all parts of the mill and permitting greater speed of reversal.

The manipulator is of the Hunt type, with side guards on each side of the mill and with special combination of turning fingers and actuating levers, of which there are three in number, mounted in conjunction with the side guard and rack beams on one side of the entering table for manipulating the ingot. The manipulator is so constructed that there are no working parts beneath the tables in the scale pit, all mechanism is located to one side of the table, opposite the operating side of the mill, the rack beams being located above the table beams, facilitating quick and easy removal for the renewal of wearing parts. It provides a simple direct means for manipulating the ingot with comparatively few moving parts and consequent light moving masses decreasing the inertia required for starting and stopping. It is operated by hydraulic power, permitting the ingot to be gripped by the side guards immediately it leaves the rolls, thereby promoting speed in rolling.

The 300-ton down cut crop shear is driven by a 75 hp ac motor and the clutch is equipped with a motor operated release. The continuous mill approach table is 88 feet long, containing 21 rollers, 14 inches in diameter with 4½x10-inch journals. The section of table next to the crop shear, 20 feet long, is hinged and counterbalanced at the shear end, being depressed with the shear as it cuts. A motor-driven screw actuated switch is provided at the entrance to the 21-inch continuous mill for deflecting the piece into the proper line of passes—this table is driven by a 50 hp motor.

The blooming mill is driven by a 42 inch and 66 inch by 60 inch horizontal twin tandem compound reversing engine, built by the United Engineering & Foundry Co., Pittsburgh. The engine is built with four bearings with center cranks on both sides, the diameter of the main shaft being 28 inches. The bed plates are unit castings including the bored guide barrel back to the point of attachment to the low pressure cylinders. The two beds being joined together at the end and along the bottom by a heavy tie section, the whole having full bearings on the foundation. Massive sole plates extend under the cylinders on each side of the engine and are firmly secured to the bed plate. The rear end of the low pressure cylinder and both ends of the high pressure cylinders are carried on breathing plates attached to the sole plates which permit the free expansion of both cylinders while maintaining their perfect alignment. The valves are tubular type, both the high pressure and low pressure valve stems are connected together in tandem in a straight line in a direct line with the valve gear, which is of the double eccentric Allen link type. The links are moved to their various positions by means of a steam cylinder, checked by a water jacketed oil cylinder, the valves of which are operated by a floating gear. This gear is inter-connected to the throttle valve so that it opens as the links move in either direction from their central position, so that the throttle opening and cut-off bar bear a fixed relation controlled by a single operating lever, designed to give the best economy and speed in operation. In the steam line between the steam receiver and the throttle valve is interposed an emergency hand operated butterfly valve with control lever in roller's pulpit and a Locke automatic overspeed shutoff valve also controlled from various push-button stations. The engine is operated under a steam pressure of 210 pounds, the greater part being furnished by the waste heat boilers at the open hearth. The exhaust from the engine is connected to a 108 inch Helander barometric condenser, furnished by the U. S. Cast Iron Pipe & Foundry Co., with an independent 12 inch by 30 inch by 20 inch Hall steam driven plate valve vacuum pump.

In the engine house are also located two 8 inch by 16 inch triplex geared Aldrich pumps, driven by a 400 hp ac Allis-Chalmers motor and a 30 inch by 10 foot accumulator furnished by the Pennsylvania Engineering Works in connection with the hydraulic system for the plant. In this building is also located an 8 inch by 11 inch by 14 inch Laidlaw horizontal duplex two-stage feather valve air compressor furnished by the Worthington Pump & Machinery Corporation, driven by a direct connected 186 hp Westinghouse, 220 volt synchronous motor, and the Bowser oiling system for the blooming mill engine and hydraulic pumps.

The Morgan continuous roughing mill comprises four stands with rolls 21 inches diameter by 48 inches long, the rolls of the mill being permanently set up with three lines of passes in them, the two outer pass lines to produce 4 inch by 4 inch billets and 8 inch by 2 inch slabs, the center line being a bullhead line capable of making slabs 3 inches thick from 6 inches to 12 inches in width.

To facilitate rolling slabs on this mill a set of 18 inch vertical edging rolls is installed between stands Nos. 2 and 3 to secure true and square edges on the slabs, which is of vital importance in their use in continuous heating furnaces to prevent their buckling when being pushed through the furnace.

The driving spindles of the mill are carried through the building partition wall into the motor house lean to which contains the bevel gear drive and the mill motor which is a 4,000 horse power Westinghouse wound rotor motor, taking 6,600 volt, 3 phase, 60 cycle current and having a full load speed of 93 rpm.

The 21 inch mill delivers to a skew connecting table 175 feet long, driven by a 40 hp motor—from this table material which has finished rolling on the 21 inch mill is transferred over a chain operated rail type transfer 160 feet long, driven by a 40 hp motor to a 180 foot long table, divided in two sections each of which is driven by a 40 hp motor and arranged to deliver material to the billet shear, or a future mill to be installed at the opposite end of the table paralleling the sheet bar mill.

The 18 inch continuous mill is a standard type Morgan combination sheet bar and billet mill, having six horizontal stands and two 16 inch vertical edging rolls.

Sheet bars and billets are sheared usually in 30 foot lengths on the Edwards flying shear, the shear table about 75 feet long being driven from the 18 inch mill with change gears in the connecting mechanism regulating the speed of delivery to correspond with the speed of the mill stand on which the section is finished.

The roll turning department is located in the motor house between the drives for the 18 inch and 21 inch mill, the equipment consisting of a 31 inch roll lathe with bed 18 feet long driven by a 15 hp motor for turning rolls for the 8 inch and 21 inch mills and a 42 inch lathe with a bed 27 feet 10 inches driven by a 30 hp motor for turning the blooming mill rolls. The lathes are direct motor driven, all gears are cut and located in an enclosed type of head stock and run in oil, and were furnished by the

A. Garrison Foundry Company. In this section of the motor house is also located the Bowser oiling system of filtering and delivering oil to the bearings of the 18 inch and 21 inch mill drives.

At the opposite end of the motor house, adjacent to the blooming mill engine room is located the sub-station containing two 1,500 kw motor generator sets supplied by the General Electric Company with space provision for a third. The sub-station receives 6,600 volt, 3 phase, 60 cycle current over a high tension line connected with the main power generating station at the blast furnace, and is converted by the motor generator set into 230 volt dc current for the requirements of all steel plant cranes, mill table drives, etc. In the sub-station are also located three 200 kva and four 750 kva self-cooled indoor type alternating current transformers, furnished by the Pittsburgh Transformer Company.

All small motors throughout the plant for cranes, mill table and auxiliary drives were furnished by the Westinghouse Electric & Manufacturing Co. and the control equipment by the Cutler-Hammer Manufacturing Company.

To supply the additional water requirements from the Ohio river, the intake and screening facilities at the existing pump house were greatly increased, the changing of the intakes and necessary dredging of the banks and river bed to allow for an unrestricted flow of water to the intake, was done by the Foundation Company. In the pump house the old vertical centrifugal pumps were removed, new suction and discharge piping was installed, connecting with two 18 inch horizontal single stage centrifugal pumps, direct connected to 700 hp, 6600 volt, 3 phase, 60 cycle, wound rotor induction motors, furnished by the Allis-Chalmers Company, and each having capacity of 16,000,000 gallons per day against 175 ft. head, there being four of these units installed at present in the pump house.

A 60 foot extension was added to the south end of the power house and two 7500 kw Curtiss steam turbine generating units, furnished by the General Electric Company, were installed in addition to the existing machine of the same capacity, one of which will be held as reserve, the other two furnishing high potential current for the steel plant and blast furnace and through its tie connection with the power station at Weirton tinplate plant, containing two 3000 kw machines, current is furnished for the operation of the river pumps and the mills at the strip steel plant. A Carrier air washer and humidifier, having a capacity of 29,000 cubic feet of washed air per minute is installed in connection with each turbine in the basement, supplying the cooling air required for the generators. This air is discharged behind a brick partition in the powerhouse basement from which it is vented to the outside through an adjustable shutter arrangement and in cold weather a portion of the warm air may be brought up through the powerhouse floor for heating the building. The turbines exhaust through 66 inch lines into two Elliott-Ehrhard barometric condensers, each equipped with two Elliott-Ehrhard steam air ejectors designed for 28 inch vacuum.

Two Alberger turbine driven centrifugal pumps each having a capacity of 5000 gallons per minute against a head of 140 ft. located on the floor of the pump pit over the storage reservoir, recirculate the water through a 24 inch cast iron line to the open hearth and mills, a 20 inch branch being taken off at the north end of the open hearth and a 20 inch and 18 inch line extending to a 30 foot diameter by 100 foot high stand-pipe located central to the mills. This standpipe furnishes additional reserve capacity and uniform head. It was furnished and erected by the Riter-Conley Company.

Condensing water for the blooming mill engine condenser is delivered through a 20 inch cast iron line from the pumping station in the power house, being recirculated by an Alberger centrifugal pump having a capacity of 7,000 gallons per minute, against a 65 ft. head, direct connected to a 150 hp Westinghouse ac, 220 volt motor.

The addition to the boiler plant of a 5-bay 100 foot extension to the boiler house in which are installed five 603 hp Stirling water tube boilers with power specialty superheaters, equipped with Westinghouse underfeed stokers, capable of burning coal to develop 200 per cent of the normal rating of the boilers continuously, each boiler being equipped with a Green radial flow, double inlet forced draft fan with a capacity of 23,000 cubic feet per minute against a 6½ inch static discharge pressure, and driven by direct connection to 50 hp 220 volt, ac Westinghouse motors.

A steel breeching, furnished by R. Munroe & Sons Manufacturing Corporation, connects the coal fired boilers with a 15 foot by 225 foot high reinforced concrete chimney with radial brick lining, built by the Rust Engineering Company.

Boiler feed water for the entire plant is furnished through a continuous hot process filtering and heating system, the water passing through three sand filters to a Cochrane feed water heater receiving exhaust steam from the turbine driven circulating pumps in the powerhouse, the turbine driven boiler feed pumps and other miscellaneous sources of supply. The heater is mounted on top of a sedimentation tank receiving the proper amount of chemical for treatment by means of a Cochrane chemical mixing tank, pumping set and proportioning device, water being delivered to the boilers by two of three Jeanesville centrifugal boiler feed pumps, installed with the filtration plant at the north end of the boiler house. A low head Allis-Chalmers centrifugal pump is provided for pumping water from the filtration plant to the open hearth boilers as previously described.

All pipe lines, with the exception of the underground cast iron bell and spigot lines, including steam, exhaust, boiler feed, blowoff, water supply lines above ground and all hydraulic piping was furnished and installed by B. Floersheim & Co., using the Crane Company American standard flanges, fittings and valves throughout.

The coal and ash handling equipment for the boiler house was furnished by the C. W. Hunt Company.

A machine shop of brick and steel construction has been provided, which includes the electric repair shop, small stores and winding room. The machine tools consist of one 60 inch Detrick and Harvey convertible open side planer, one 36 inch by 24 foot American lathe, two 24 inch by 16 foot American lathes, two 20 by 2 foot American lathes, one 5 foot Niles-Bement-Pond full universal radial drill, one 62 inch King vertical boring mill, two 3 foot American radial drill presses, two 25 inch Silver upright sensitive drills, one No. 3 Cincinnati milling machine, three 24 inch Cincinnati heavy duty back geared shapers, one 3 inch Acme bolt cutter, two 5 hp U. S. Electric Tool Company ball bearing floor grinders, one No. 10 Racine high speed saw, one Oster 2½ inch to 8 inch pipe machine, one No. 2 Oakley tool cutter and grinder and a 6 inch by 6 inch Peerless high speed power saw—all tools being provided with independent direct motor drives. A portable 330-ton hydraulic press furnished by the Hydraulic Press & Manufacturing Co., is also installed in the machine shop.

WITH THE EQUIPMENT MANUFACTURERS

NEW AUTO-TRANSFORMER STARTER MADE BY CUTLER-HAMMER

Central stations almost universally require that standard squirrel cage induction motors of 5 hp rating or over be provided with starting devices in order to avoid the line disturbances resulting when the motor is started by connecting directly to the supply system. For various reasons the auto-transformer starter or compensator is generally considered to be the most satisfactory device for this service. The squirrel cage motor, because of its inherently simple construction, will withstand unusually severe service with only an occasional overhauling. This cannot be said of starting devices as a class and, therefore, where squirrel cage motors are used the weakest link in the power system is generally the starter or controller. The value of a dependable starter is generally realized in those industrial plants where a shut-down, even if for only a half hour, is costly in terms of wages and finished material.

The Engineering Department of the Cutler-Hammer Manufacturing Company of Milwaukee, has devised an auto-transformer starter of unusually rigid construction to meet the severe requirements of the large industrial plant and mine, as well as that of the small mill and factory. The simple steel construction—using no wood or castings whatsoever—the absence of flexible moving leads, and the ease of inspection of the contacts and adjustments of the relays, enable this starter to give continuous and satisfactory service at a low upkeep cost. This starter is shown in the accompanying illustrations, and consists of two auto-transformers, commutating mechanism, low-voltage release and duplex overload relay, all enclosed in a sheet metal case with the operating lever outside. The case is strongly reinforced with angle iron, and has a hinged cover which can be lifted to expose the transformers and relay. The transformers and case are carried directly on the supporting brackets and may be readily mounted on the wall, switchboard, or any post or pedestal.

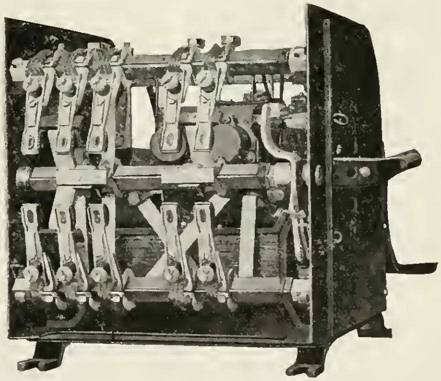
The starter is operated by moving the operating lever forward to the starting position and then backward to the running position, where it is held in place by the low-voltage mechanism. Interlocks prevent moving the lever directly to the running position. If released in the first or starting position, the lever is returned to neutral by a spring. It may be locked in the neutral position to prevent unauthorized operation.

The auto-transformers connected in open delta are used for both two and three phase service. The special construction of the transformer core allows either coil to be easily and quickly replaced. Each coil is provided with three accessible taps which give 50, 65 and 80 per cent of full line voltage.

The oil-immersed commutating mechanism is placed at the bottom of the case below the transformers and may be exposed for inspection by the removal of the oil pan, which is made a simple one-man job by means of the combined handle and holding clamp used. An ample head of oil is maintained above the contacts and a double horizontal break is provided in each line. Breaking the circuit horizontally confines the arc between the copper contacts and prevents burning of parts not designed for that service. The sliding action of the contacts keeps them clean and breaks any film of oil which might form between them and produce destructive arcing. The contacts are carried on steel supports clamped on insulated square steel bars. No wood or other flammable material is used in the construction. The stationary contacts are drop forged pieces of copper carried on fingers of standard C-H construction. These fingers are of the non-stubbing type, and are easily adjusted and renewed. The moving contracts or segments are short copper strips, reversible so as to give double the normal amount of service.

The low-voltage mechanism is mounted inside the case on the right hand side. A wire from the armature of the release coil extends through the case near the operating handle and is bent to form a hook, a slight pull on which releases the starter and returns the handle to neutral. Remote control of stopping may be obtained by inserting one or more normally closed push button switches in the low-voltage coil circuit. Pressing any one of the buttons releases the starter mechanism.

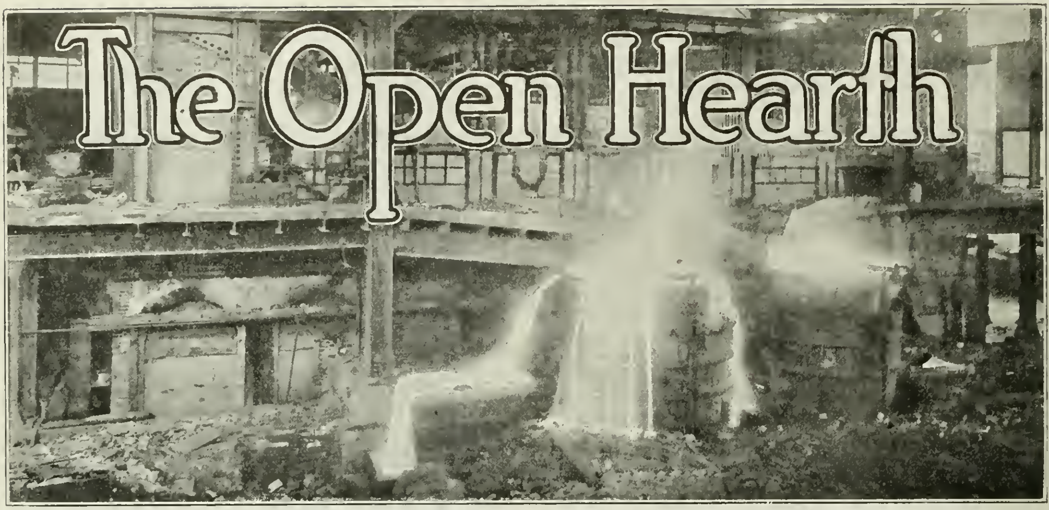
A duplex overload relay with a true inverse time limit movement is mounted inside the case on the transformer assembly in such a position that adjustments for time and current values can be readily made. This duplex relay is equivalent to two overload relays, each in series with one of two phases. The Underwriters' rules do not require installing a disconnecting knife switch or circuit breaker ahead of this starter when thus equipped, because the starter completely disconnects the motor from the supply line when released by an overload.



Under view of starter showing simplicity of finger construction and arrangement. The fingers are non-stubbing and are readily adjusted for wear.

Rigid copper leads are used throughout, with the exception of four flexible stationary leads to the transformer taps and low-voltage coil. The flexible leads are out of the way of the moving parts; therefore all danger of leads becoming broken or grounded by bending or rubbing is eliminated.

These starters are made in various sizes for the operation of two or three phase induction motors rated between 5 and 100 hp on standard commercial voltages between 110 and 2,200 and at frequencies of 60, 50, 40, 33 and 25 cycles per second.



The Open Hearth

Samuel A. Benner, formerly vice president of the Federal Steel Export Company, New York, and previously general manager of sales of the American Steel Export Company, New York, is to become president of the Empire Tube & Steel Co., College Point, L. I., it is announced. Mr. Benner's experience in the iron and steel industry embraces a period of 33 years.

V V

J. C. Jenkins has been elected president of the Belding Foundry Company, Belding, Mich.

V V

F. C. Milliken, who has been connected with the Alan Wood Iron & Steel Co., Philadelphia, for many years, has been appointed assistant to the president, W. W. Lukens.

V V

F. P. Wood, vice president of the Burlington Steel Company, Ltd., Hamilton, Canada, has been elected president, succeeding the late Sir Frank Baillie. W. D. Ross has been elected vice president to fill the vacancy caused by Mr. Wood's promotion.

V V

R. M. Marshall has resigned as blast furnace superintendent at Coatesville, Pa., for the Midvale Steel & Ordnance Co., to become general manager of the American Manganese Mfg. Co., in charge of the latter's operations at Dunbar, Pa., effective February 1. M. J. Scammel resigned recently as general superintendent of company's plant at Dunbar.

V V

L. A. Lenhart, recently made vice president of the Youngstown Steel Car Company, Niles, Ohio, has resigned as plant manager of the General American Tank Car Corporation, East Chicago, Ind.

V V

Louis A. Way, who has been made assistant to the president of the Duquesne Steel Foundry Company, Pittsburgh, in charge of sales, had been with the company 16 years prior to going with the Lewis Foundry & Machine Co., Pittsburgh, from which he resigned as works manager February 1.

V V

I. P. Blanton, assistant to the president of the Kelly Nail & Iron Co., Ironton, Ohio, has been made general manager of the company. He relieves the president, Oscar Richey, who was also general manager, of the active management of the company. Mr. Richey's health has required a lessened strain of duties.

V V

J. H. McElhinney, engineer in charge during construction of the new tandem rolling mill of the Columbia Steel Company, Elyria, Ohio, has been made assistant manager of the company. Formerly he was assistant engineer of the Youngstown Sheet & Tube Co., Youngstown, Ohio.

V V

Frank L. Klingensmith, vice president and treasurer of the Ford Motor Company, Detroit, and for 15 years associated with the company, has resigned, declaring he is not in accord with some of the contemplated future business policies of the company. Charles A. Brownell, advertising manager of the Ford Company, also has resigned, and it is reported W. F. Knudson, production manager, and B. F. Craig, secretary, have tendered their resignations. Charles E. Sorenson, head of the tractor plant and blast furnaces, will succeed Mr. Klingensmith as vice president, it is reported.

V V

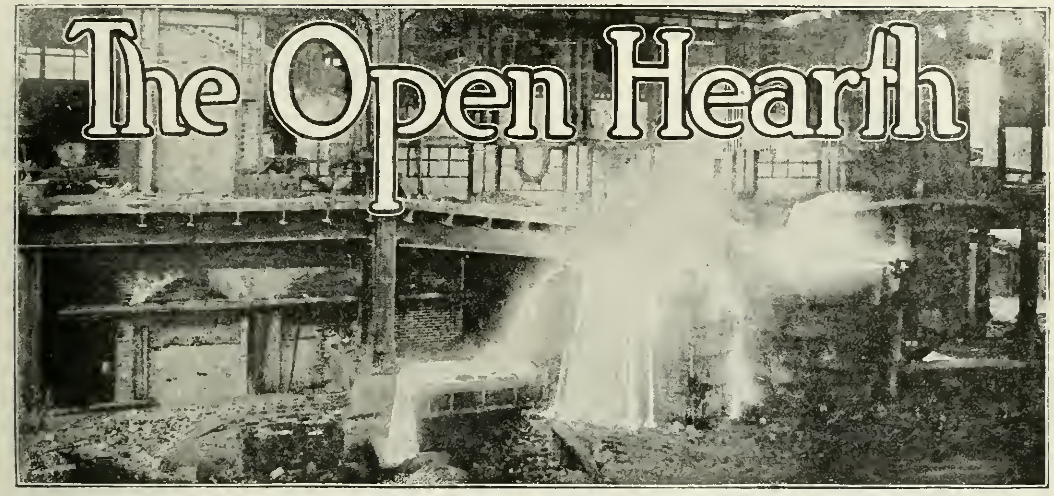
H. Donald Dickinson, formerly superintendent West Penn Forge Company, Pittsburgh, has been appointed assistant to E. B. Rouse, superintendent Chester Works, American Locomotive Company.

V V

Charles K. Nichols, for the past 10 years general superintendent of the West Penn Steel Company, Brackenridge, Pa., has been named vice president and general manager of the company, to succeed John McGinley, who died January 29. Mr. Nichols has been active in the steel industry in an operative way since early manhood, having worked up through the ranks. At one time he was a roller at the Vandergrift, Pa., works of the American Sheet & Tin Plate Co., and when the late Mr. McGinkey became general superintendent of the Allegheny Steel Company, Brackenridge, Pa., Mr. Nichols served under him in the capacity of sheet mill superintendent. He subsequently went along with Mr. McGinley when the latter, with others, organized the West Penn Steel Company.

V V

Alexander England has been named chief engineer of the Westinghouse Air Brake Company, Wilmerding, Pa., to



The Open Hearth

succeed S. W. Dudley, who resigned February 1, to join the faculty of the Yale University as professor of mechanical engineering. Mr. England has been affiliated with the Westinghouse Air Brake Company for 22 years and had held the position of assistant chief engineer since 1914. He was born in Dundee, Scotland, and served an apprenticeship in marine engineering with the Scotch shipbuilding firm of Pierce Bros. He subsequently earned a diploma in mechanical engineering from the City and Guilds of London Technical Institute. Coming to the United States in 1887, he became identified as assistant superintendent with the Thomas Carlin's Sons, Pittsburgh, hoisting engines and machinery, and later became superintendent of the Specialty Mfg. Co., Pittsburgh, machine builder. He assisted in the reconstruction of the Eliza furnace plant, Jones & Laughlin Steel Co., as engineer in charge of designs for equipment in handling coal and coke. Several changes as the result of Mr. Dudley's resignation and Mr. England's promotion have been announced. R. E. Miller, engineer of tests and inspection, has been promoted to superintendent of tests and inspection; W. E. Dean, assistant engineer of tests, has been made engineer of tests; A. A. Mackert, chief inspector, has been made engineer of inspection.

√ √

W. H. Baker has been elected a dircetor of the Electric Alloy Steel Company, Youngstown, Ohio. He is also secretary, treasurer and general manager of the Universal Steel Company, Bridgeville, Pa.

√ √

Thomas S. Hutton, for several years connected with the Southern California Iron & Steel Co., Los Angeles, Cal., has been made Pacific Coast manager for the Ludlum Steel Company, Watervliet, with offices in the Rialto Building, San Francisco.

√ √

Henry Wick of Cleveland has been elected a director of the Elyria Iron & Steel Co., Cleveland, succeeding Frank R. Guyon, who resigned from the company.

√ √

Robert M. Kilgore, who for the past two years has been assistant manager of sales at Pittsburgh for the Jones & Laughlin Steel Co., has been transferred to the company's New York territory. He succeeds H. F. Halloway, who retires on account of his health. Mr. Halloway has been affiliated with the Jones & Laughlin Steel Co. since about 1898.

√ √

R. A. Kenworthy, Jr., has been elected secretary-treasurer of the Newton Steel Company, Newton Falls, Ohio. J. L. Harrison has succeeded Mr. Kenworthy as general manager of sales, with offices in the Wick Building, Youngstown, Ohio. G. H. McVey, formerly associated with the sales organization of the Allegheny Steel Company, now is with the Newton Steel Company in the same capacity.

√ √

G. Gordon Green, formerly blast furnace construction engineer Tata Iron & Steel Co., Ltd., India, sailed from Seattle, January 27, to assume similar duties with the Lungyen Mining Administration of China, which is erecting near Peking a 250-ton blast furnace of Pekin & Marshall's design.

√ √

A. W. A. Eden, formerly assistant structural engineer with Westinghouse, Church, Kerr & Co., Inc., has become affiliated with the Harris Structural Steel Company, New York.

√ √

George F. Wright, formerly vice president Wickwire-Spencer Steel Corporation, Worcester, Mass., and for the past year secretary of its operating committee, has resigned. He plans to take a vacation and then enter business for himself in Worcester.

√ √

Lewis Taylor, assistant chief engineer McClintic-Marshall Company, Pittsburgh, has been appointed chief engineer of the company, succeeding the late Paul L. Woelfel. Mr. Taylor has been identified with McClintic-Marshall Company since shortly after its organization and has held a position as assitant chief engineer for the past 12 years. His experience includes an important part in the construction of most of the large bridges and other structures erected by the company. He graduated from the University of Pennsylvania in 1900 and is a member of the American Society of Civil Engineers' Society of Western Pennsylvania, and the American Society for Testing Materials.

THE BASIC OPEN HEARTH MELTING SHOP EQUIPMENT AND PRACTICE.

(Continued from page 217.)

phosphorus is necessary after the carbon is removed, the bath will contain large amounts of dissolved or combined oxygen when ready to teem, whereas if the phosphorus has been rapidly removed during the early stages of the process, by the highly oxidizing conditions prevailing in the furnace and the operation carried on at a low temperature, then when the phosphorus is eliminated there is still carbon in the bath and this carbon will react with the ferrous oxide dissolved in the metal and slag reducing its content to a figure approaching more nearly that realized in ordinary open-hearth practice, with the result that the metal leaving the furnace will be lower in dissolved oxides and will not require as much treatment in the ladle by deoxidizing agents and will be in consequence a superior product. It is important, then, to control the temperature of the bath, in order that the exothermic phosphorus reaction may have preference over the carbon elimination. If the Bessemer metal is very hot, opening the furnace doors and cutting off the flame during the initial stages of the boil will hardly be sufficient to reduce the temperature to that proper for dephosphorization when such large masses of metal are involved as in modern duplex plants, hence it is important that the working of the converter be carefully controlled in this respect.

The whole open-hearth stage of the duplex process is very rapidly carried out, heats following one another at intervals of two or three hours. The enormous output possible will be easily realized.

Some leading particulars of a few representative duplex plants in the States are tabulated in Table 11 to give an idea of the nature of the equipment now used.

FORCED FITS AND SHRINK FITS.

(Continued from page 218.)

Old wheels which have been pressed on and off shafts, require a far greater pressure when being forced on another shaft; this is due to the fact that the metal has become surface-hardened by the pressure which it has already sustained, and on this account, it takes double the pressure to force it on a shaft as contrasted with that of a new wheel of the same shaft diameter. Shrink fits are used in cases where the greatest possible binding effects are desired, they being used extensively by machinery manufacturers and also in railway locomotive shops for putting tires on the driving wheels of engines. Repair forces in various factories also use shrink fits to hold parts of machines together in emergency work, it proving to be very effective.

As in force fits, the allowance for a shrink fit depends to a great extent upon the thickness and amount of metal around the hole, as this has a great influence upon the stresses in the hub at the bore of a wheel and shaft that has been put on by shrinkage. The higher the heat of the outer member, the greater the shrinkage allowance, as the expansion is greater when a piece of steel is heated to 1200 degrees F. than the same metal would have if it were only heated to 800 degrees F. It is thus possible by this means, to control the amount of adhesion between a wheel and a shaft put together by the shrinkage method; but in practice, there are limits beyond which it is not safe to go, on account of the mechanical stresses set up when the metal is cold. Should the shrinkage allowance exceed the elastic limit of the steel, either a permanent set will occur, with the metal around the hub of a wheel in a strain, that is likely to develop into a crack by jarring at its weakest point, or the pressure on the hub may be so great that its ultimate strength is exceeded and it will burst after the shrunk parts are cold.

For the general run of machine work, an allowance of about 0.004 of an inch for each inch of internal diameter of a hole in a wheel will give satisfactory results. On account of their large diameters, railway locomotive tires are shrunk on with an allowance of from 1/64 to 1/32 inch per foot of diameter.

NEW PUMPLESS BLOW TORCH.

Very unique blow torch has appeared on the market known as the Pumpless Blow Torch and sold through the Tri-State Sales Company in New York. It has several very interesting points which make its use in the steel industry very important. Following are some of the interesting features of the same:

It requires no preheating or pumping. It throws out a full steady clean green flame 2246 degrees F. in heat and is easily regulated. It can be used upside down or sideways without going out. It can be run on the 45 mile gale. It is practically indestructible. It will heat 1¼ inch steel red rod in three minutes. Any type of liquified gas can be used. It is always ready for use.

While it has only been on the market for a period of a few months many steel companies including Carnegie Steel Company, Whitaker-Glessner Company, Mesta Machine Company and others use it throughout their plant. It is especially helpful to the steel plant electricians, plumbers, painters, tinners or machinists and can be operated most economically in all respects.

PRODUCTION TOPICS

WHAT A "COST SYSTEM" SHOULD DO FOR YOU.

Part of the work of the Fabricated Production Department is to assist its organization members in securing for the industries they represent cost systems as practicable, yet as simple and uniform as possible. We shall not either devise or install cost systems but by coöperative study of each situation, aided by the contributed experience of trade organizations and expert knowledge of the subject, help those who are disposed to help themselves.

Purpose and Value of Cost Accounting.

Individuals' memories are limited in the number of accurate records which they can retain. Business consists of transpiring events, all of which must be properly attended to. The solution of the problem of securing reliable records of many transactions without depending upon the fallibility of memory has been through systematic methods for conducting the operations of business. One of the very important matters relating to business operations, and one in which a number of records are involved is cost accounting.

As An Insurer of Profits.

Primarily, a business to exist must make money. This means that something must be disposed of for more than it has cost. Every manufacturer, therefore, is vitally concerned with the two items—cost and profit. The problems presented in labor, materials, production costs, and keen competition have made it necessary for a manufacturer to determine and constantly to know the cost of his product in order that his business may continue to be a profitable one, and earn the margin of profit desired. There is a definite dividing line between profit and loss, and the location of this dividing line can be and should be accurately determined.

For Business Control.

Cost accounting is an accurate method for arriving at the cost of producing a complete and saleable commodity and delivering it to the carrier for transportation, reporting in usable records all of the various elements which go to make up these costs. Records of costs are valuable in themselves, yet it is the detailed information which they contain, available for ready reference, which is of utmost value. Accurate information regarding the various elements which go to make up costs, as contained in cost records, automatically eliminates arbitrary, empirical, or guess costs which prevail to a surprising degree among many manufacturers. The cost system, like an X-ray picture, brings to light imperfect internal conditions and suggests correction.

Increases Production.

Among the many ways in which cost keeping is an aid to production are the following: It brings to light inefficiencies in system by calling to attention the cost of its operation and points out equipment that has become inadequate by showing an excessive cost of product coming therefrom; it points out employes who are below the standard required, and permits of performances being kept within certain limits by watching the accumulation of costs. Increased production depends largely on the intimate knowledge the management has of all elements in their manufacturing operations which can only be supplied through an adequate cost system. It enables them to establish proper control and increase output as warranted by the cost record.

Checks Variations From Standard Practice.

In many plants considerable sums of money are spent to establish a standard practice of operation. From time to time certain variations from the established standard practice occur, affecting costs in an adverse way. Timely cost reports showing what is happening, rather than what has happened, sugest immediate correction of such inefficiencies. It is not sufficient that executives simply know that expenditures are excessive; they should be supplied with information to determine exactly where these excessive expenditures occur and take action. Definite responsibility for expenditures as well as the authority to make the expenditures should be fixed by an adequate system of cost accounting.

Helps in Controlling Overhead or Burden.

Overhead, or burden, consists of expense items which cannot be directly attributed to some particular product. It is composed of indirect labor and material, rent, etc. Overhead being variable, as related to output, and forming a material portion of a plant's expense, it is necessary that control over these accounts be rigidly kept.

Control is possible only when accurate knowledge of the amounts entering into each item composing overhead are known. Guessing, or estimating amounts of overhead, as well as arbitrary distribution without a sound basis for the allocation is uncertain and leads to unexpected results. Sales price does not affect overhead, but the amount of overhead definitely and absolutely affects sales price.

A factory manager should have before him detailed cost reports showing the expenditures necessary to produce articles. With this information at hand, he is in a position to note the varables and put into operation the movements necessary for their satisfactory control. In this respect, the cost system is similar to the nerve system of the body, its function being to transmit information regarding conditions in the entire plant to some cenral individual or body.

Promotes Intelligent Competition.

No one enters business to fail but the majority who do lose out do so from various causes, but principally because they disregard the question of costs. Your worst competition is largely from those who do not know what it costs them to produce and do business. When normal production returns, competition will force closer margins and costs must then be known. Why not now?

Determines Unprofitable Lines:

The manufacturer who bases the sales price of his product on competition without regard to real cost, stands to sell his product at a closer margin than he desires and possibly at a loss. Whether the margn of the profit is ample or not the existing conditions are not known until the date when damage done is beyond repair.

It is generally conceded that unprofitable lines should be discontinued. Where a variety of articles are manufactured in a single plant a cost system offers the only opportunity for determining positively those lines which are not profitable. Where a single article is manufactured timely information regarding costs can forestall a calamity.

Issued by the Fabricated Production Department Chamber of Commerce of the United States, 1920.

TRADE NOTES

The Combustion Engineering Corporation announces the opening of a branch office in Atlanta, Ga. This office has been placed in charge of A. A. Hutchinson, who has had an extensive experience in the engineering field and is widely known in the South, having been actively engaged in the field of combustion generally for the past 14 years and during that period been in charge of important development work.

The Ohio Electric & Controller Company, Cleveland, O., wish to announce that they have appointed Arthur H. Abbott, 88 Broad street, Boston, Mass., as their New England representative for the sale of Ohio Mill Type Lifting Magnets and Ohio Ball Bearing fractional sized motors.

The Charles Austin Hirschberg, Inc., handling Keller Mechanical Engraving Company, advise that their address is 150 Nassau street, New York City, instead of 120 Liberty street, New York City.

Arthur G. McKee & Co., 2422 Euclid avenue, Cleveland, O., have been awarded a contract by the Emporium Iron Company, Emporium, Pa., covering the precision of a new hearth jacket and cooling plates, for their furnace, new hot blast stove fittings, etc.

N. B. Payne & Co., 25 Church street, New York, dealers in electric cranes and hoists, have extended their lines of material handling machinery to include the portable conveyors of the A. C. Warner Company, Philadelphia, Chicago automatic coal elevators and McKinney-Harrington package pilers and car loaders.

Edmund Otto, for several years secretary of the Hardware and Supply Company, and prior to that associated with Manning, Maxwell & Moore, Inc., New York, is now associated with N. B. Payne & Co., in this branch of their business.

E. D. Kellogg has recently been appointed New Jersey representative for the Conveyors Corporation of America, formerly American Steam Conveyor Corporation, manufacturers of machinery for handling coal, sand, gravel, ashes and other loose, bulky materials. He will handle "The American Trolley Carrier" and "The American Steam Jet Conveyor" in the northern half of the State, but will make his headquarters at their Eastern office, 110 West Fortieth street, New York.

L. W. Rench has been appointed secretary and general manager of the International Oxygen Company, succeeding Eugene Schoen, resigned.

The Conveyors Corporation of America, formerly the American Steam Conveyor Corporation, Chicago and New York, announce that S. D. Inman has been placed in charge of the engineering and design of their American Trolley Carrier, monorail conveying equipment for handling coal, ashes, sand, gravel, and like bulky materials from railway car to pile, bin or bunker.

Frank Hodson, president of the Electric Furnace Construction Company, Philadelphia, has been elected member of the executive committee of the Philadelphia Foundrymen's Association.

F. J. Ryan & Co., Franklin Trust Building, Philadelphia, specialists in electric heating problems in both the chemical and metallurgical industry, announce the electon of the followng departmental executves: S. H. Ourbacker, director of engineering; F. A. Hall, director of sales; T. B. Bechtel, director of construction.

Following the annual stockholders' meeting of the Crescent Refractories Company of Curwensville, Pa., announcement was made of a merger of the George S. Good Fire Brick Company and the Clearfield Clay Working Company with the Crescent Refractories Company's properties. Consolidation of these properties brings together three important Clearfield county fire clay and coal holding properties. The output of the plants now operated by the corporation reaching 240,000 brick per day and marks another step forward in fire clay industry of this region. James B. Graham, president of the Northern Trust Company of Wiliamsport, Pa., has been elected president of the board of managers of the Crescent Refractories Company of Curwensville, Pa.

Carl A. Wendell, for the past few years chief engineer of the American Ore Reclamation Company, 71 Broadway, New York, and previous to that connected for several years with the U. S. Steel Corporation, has been retained by the General Briquetting Company as consulting engineer, in connection with their flue dust and ore biquetting development. He will also specialize in coal washing and, as a natural adjunct thereto, in coal briquetting.

The W. R. Miller Company, formerly of the House Building, have moved to their new office building, Boggs and Jasper streets, Mt. Washington, Pittsburgh, Pa. The new phone number is Hill No. 439. Ten minutes ride from Fifth avenue and Wood street to South end of tunnel.

Cutler-Hammer Company annunce that G. S. Crane, who has been manager of the Cleveland office, will become manager of controller sales at the main office in Milwaukee. L. B. Timmerman will be in charge of the Cleveland office, and will act in the capacity of assistant to A. G. Pierce, manager of the Central District. The Cincinnati office will become a part of the Central District with R. I. Maujer as branch manager. E. N. Lightfoot will assume the title of manager of the heating department, with headquarters at the New York works, and will be in full charge of all matters relating to the sale of electrical heating devices.

Effective at once, Robert C. Weller is appointed general sales manager of The Lakewood Engineering Company, with headquarters at Cleveland. Mr. Weller is in full charge of sales work.

Effective March 1, Mr. Carlton R. Dodge is appointed Western sales manager of The Lakewood Engineering Company, with headquarters at 1215 Lumber Exchange Building, Chicago.

Freyn, Brassert & Co., Chicago, have been given a contract by the Rogers Brown Iron Company, Buffalo ,for work in connection with the remodeling of their No. 1 furnace. The general arrangement of the furnace, below the mantle, inclusive of bustle pipe and tuyeres, is to be changed and new hearth jacket, tuyere jacket and iron and steel work for both is to be placed. There will also be material modfication and enlargement of furnace lines and capacity.

Lawrence Wilkerson Wallace was elected secretary of American Engineering Council at the meeting of the executive board in Syracuse, N. Y., on February 14, succeeding L. P. Alford of New York, who has been acting secretary since the formation of the council in Washington on November 19, 1920. Mr. Wallace has been one of the most active figures in the council and from the time it was organized has been its treasurer. As vice chairman of the council Mr. Wallace has been directing the work of the committee on elimination of waste in industry, one of the principal committees of the council whose scope following the Syracuse meeting will be greatly broadened.

TRADE PUBLICATIONS

Frank D. Chase, Inc., Chicago, have recently compiled and issued a highly interesting and illuminating booklet entitled "Factories That Fit." The purpose of this booklet is to get across the Chase conception of sound engineering design in factory construction.

The Griscom-Russell Company, 90 West street, New York, has recently published a 29-page illustrated booklet entitled "The Cooling of Quenching Oil in the Heat Treatment of Steel," by Kenneth B. Millett. This describes in a very readable manner the necessity for heat treatment, the various quenching mediums and systems commonly used, the advantages of continuous circulation of the medium and the excellent adaptability of the multiwhirl cooler to the cooling of quenching oil. Typical installations are featured, showing the layout of the piping with recommendations for the proper size and number of coolers to meet the requirements.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., APRIL, 1921. No. 4

Boiler Operation at the Power Plant of The Mesta Machine Company

Description of How Close Observation Led to the Installation of Mechanical Devices and Instruments, and the Economy That Resulted.

By C. FISCHER,
Supt. of Power, Light and Heat, Mesta Machine Company.

THE vast amount of fuel used daily, especially coal, in the generation of steam, has brought before the public in general and the plant owner and operating engineer in particular the necessity of finding and adopting such means and methods as will help to increase the overall boiler efficiency and to reduce the fuel losses.

It is therefore essential that the operator be acquainted with the basic principles entering into the efficient use of the particular fuel, and that such instruments and apparatus are put at his disposal as will enable him not only to check his operation at any time, but also to have full control of the varying conditions, such as are met with during operation, and to keep permanent records.

Since the boiler as in general use at present is accepted as a highly developed and efficient heat absorbing apparatus, particular attention has to be paid to the heat production in the furnace, as by far the greatest part of the losses occur during the process of producing and guiding the heat.

The production of heat is a chemical process, called combustion. During this process the combustible elements or compounds of the fuel combine with the oxygen. This combustion however can only take place at the proper temperature, called the ignition temperature of the combustible. It is consequently necessary for the proper amount of oxygen to be present at the ignition temperature of the combustible matter, before combustion can take place. The ignition temperature of the various combustible substances varies.

The oxygen necessary for combustion is taken from the air, which is a mechanical mixture of oxygen, nitrogen and small amounts of other gases. The generally accepted amounts existing in the air are:

	Volume per cent	Weight per cent
O_2 Oxygen	21.00	23.15
N_2 Nitrogen	79.00	76.85

For every pound of oxygen required for combustion 3.32 lbs. of nitrogen or 4.32 lbs. of air have to be introduced into the furnace. Nitrogen has no useful purpose during the process of producing heat, but is an element which absorbs heat, thus entailing a direct loss. The success of burning the fuel efficiently therefore, depends largely on the proper amount of air supplied. How important a part the air supply plays in the heat producing process will be more fully discussed later.

As the boiler plant, of which the operation is to be analyzed later, is a coal fired installation, the fuel to be considered will be bituminous coal from the Pittsburgh district.

The combustible element most prominent in coal is carbon, of which the atomic symbol is C. When one carbon atom C combines at the proper temperature with two atoms of oxygen of the atomic symbol O it is said that combustion is complete. The product of combustion is called carbon dioxide having the molecular symbol CO_2.

$$C + 2O = CO_2$$

The atomic or combining weight of carbon is 12 and that of oxygen is 16, therefore

$$12 + (2 \times 16) = 44$$

12 lbs. of carbon plus 32 lbs. of oxygen form 44 lbs. of carbon dioxide.

One pound of carbon therefore requires 2.667 pounds of oxygen for complete combustion, and the weight of the product of combustion must be $1 + 2.667 = 3.667$ pounds of carbon dioxide. One pound of carbon dioxide consequently consists of:

$$\frac{12}{44} = 0.2727 \text{ pounds of carbon and}$$

$$\frac{32}{44} = 0.7273 \text{ pounds of oxygen or any weight of}$$

CO_2 is composed of 27.27 per cent C and 72.73 per cent O_2.

Since one pound of oxygen is contained in 4.32 pounds of air, the amount of air required for the complete combustion of one pound of carbon is:

$$2.667 \times 4.32 = 11.52 \text{ pounds.}$$

and since every pound of air contains 0.7685 pounds of nitrogen, the total amount of nitrogen is:

$$0.7685 \times 11.52 = 8.853 \text{ pounds.}$$

The total weight of flue gases for the perfect combustion of one pound of carbon amounts to:

$$\begin{array}{l} 3.667 \text{ lbs. } CO_2 \\ 8.853 \text{ lbs. } N_2 \\ \hline 12.520 \text{ lbs.} \end{array}$$

The above represents the process, expressed in weights, for perfect combustion of carbon, that is to say, each carbon atom has been supplied with two atoms of oxygen by supplying just the proper weight of air, no more nor less. If more air had been supplied than was necessary to satisfy each carbon atom for its affinity for oxygen, the total weight of the flue gases would have been increased by that amount of excess air, and this amount of excess air would have absorbed some of the heat produced in addition to that absorbed by the 8.853 pounds of nitrogen, which had to accompany the 2.667 pounds of oxygen necessary for the complete combustion of one pound of carbon. Although combustion can be complete with an excess amount of air, it can no longer be perfect, owing to the presence of the excess air.

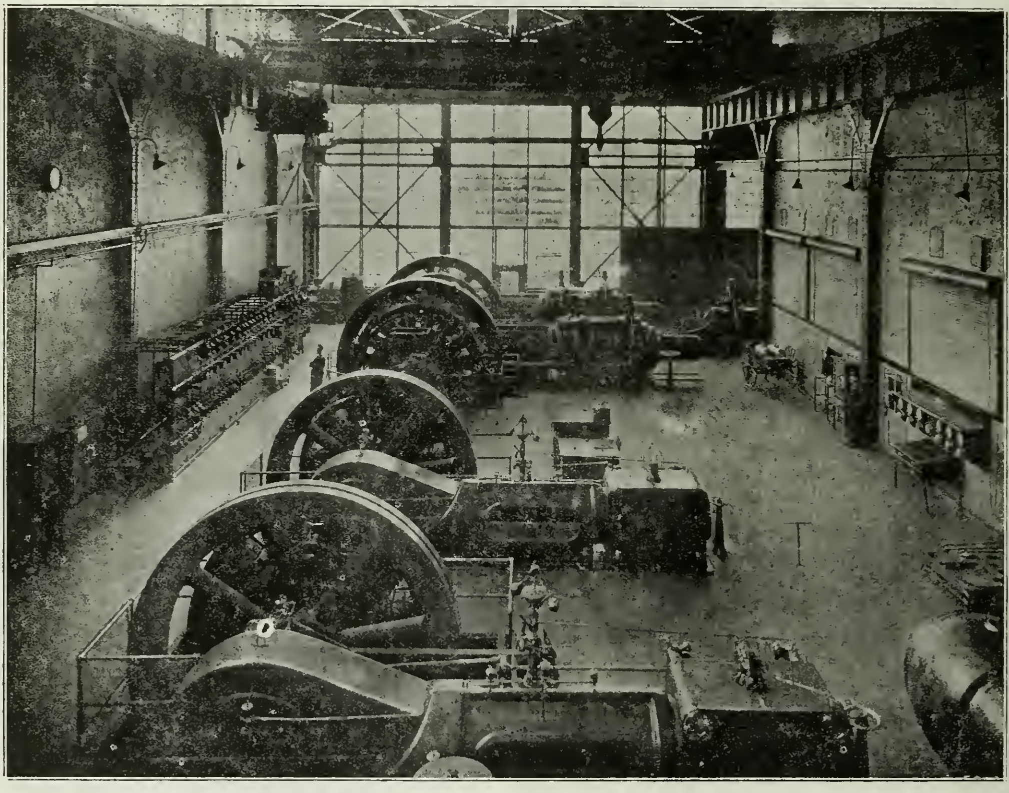


Fig. 1—View of Power House looking toward Mesta Unaflow Engines. Westinghouse switchboard to the left of photograph.

During the process described above, heat is produced and the amount of heat produced in burning one pound of carbon complete is 14,600 Btu. This represents the quantity of heat, the unit of which is that amount necessary to raise the temperature (quality of heat) of one pound of water 1 degree F. The more correct and now generally accepted definition of the Btu is the $\frac{1}{180}$ amount of heat required to raise the temperature of one pound of water from 32 to 212 degrees F. at atmospheric pressure.

If the air supplied during the process of combustion is insufficient to satisfy the affinity of carbon for oxygen, combustion is no longer complete, and instead of forming carbon dioxide CO_2 carbon monoxide having the molecular symbol CO is the result.

$$C + O = CO$$

$$12 + 16 = 28$$

The amount of oxygen involved during this combination is 1.333 pounds per pound of carbon and the resulting weight of the product of combustion is 2.333 pounds of CO. The weight of air is therefore

$$1.333 \times 4.32 = 5.76 \text{ pounds}$$

and nitrogen

$$5.76 \times 0.7685 = 4.427 \text{ pounds.}$$

The weight of flue gases for incomplete combustion of 1 pound of carbon is therefore composed of:

2.333 lbs. CO
4.427 lbs. N_2
6.76 lbs.

The heat evolved during the process of incomplete combustion is 4450 Btu.

Should the CO so formed, pick up during its passage through the furnace another atom of oxygen, combustion can be completed, provided the temperature is right. If therefore the 2.333 pounds of carbon monoxide are supplied with the necessary oxygen amounting to 1.333 pounds, 3.667 pounds of CO_2 are formed, and the heat produced must be 14,600 — 4450 = 10,150 Btu. The heat produced in oxidizing 1 pound of CO forming CO_2, consequently amounts to $\frac{10,150}{2.333} = 4359$ Btu.

The amount of oxygen required during this combination is $\frac{16}{28} = 0.57$ pounds, the weight of CO_2 equals 1.57 pounds. The weight of air necessary to supply the oxygen is 2.47 pounds and the weight of the accompanying nitrogen is 1.90 pounds.

The second element in coal to be considered is hydrogen. Hydrogen has to be completely oxidized or not at all, therefore, if the air supply is not sufficient, part of the hydrogen will oxidize and the rest will leave the flues unburned. The atomic symbol of hydrogen is H and the atomic weight is one, while the molecular symbol is H_2 and the molecular weight is 2. The product of combustion is H_2O, two atoms of hydrogen combine with one atom of oxygen to form water vapor.

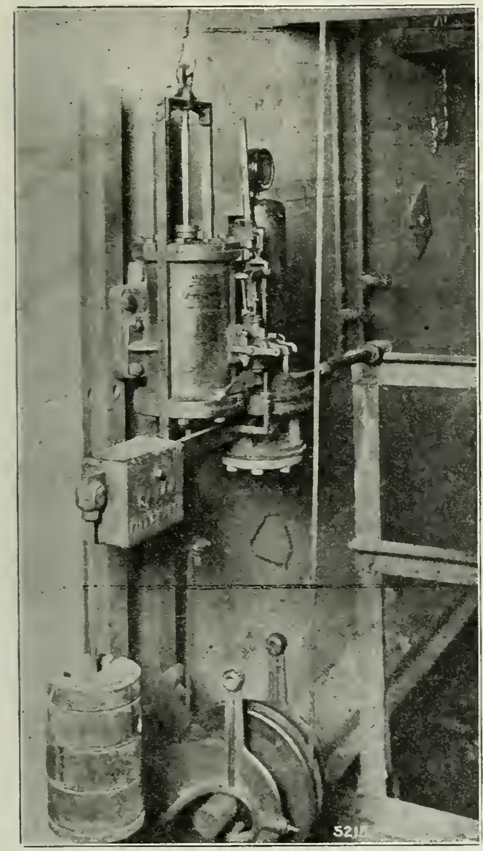


Fig. 2—View of Hagan Regulator.

$$2\,H + O = H_2O.$$

Since the combining weights are 1 and 16 respectively, 2 pounds of hydrogen require 16 pounds of oxygen to form 18 pounds of water vapor

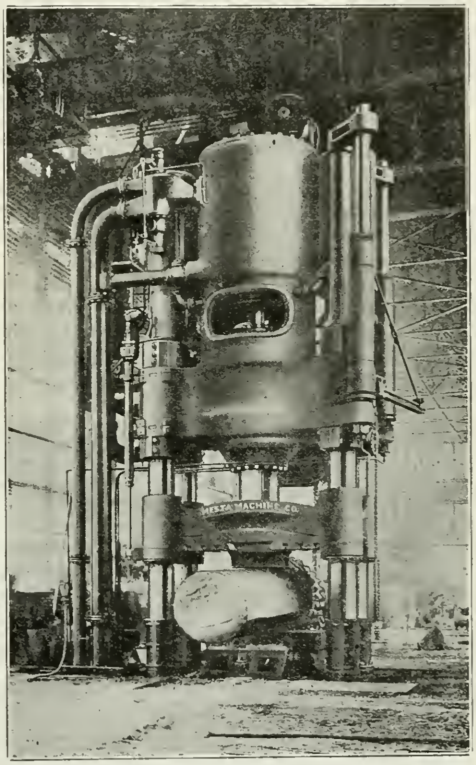


Fig. 3—View of 2,000-ton Mesta press used in forge shop.

$$(2 \times 1) + 16 = 18$$

Consequently 1 pound of hydrogen requires 8 pounds of oxygen, or 8 × 4.32 = 34.56 pounds of air. With this weight of air 34.56 — 8 = 26.56 pounds of nitrogen have to be supplied. The weight of the product of combustion H_2O amounts to 9 pounds and the total weight of the flue gases are:

9.00 lbs. H_2O
26.56 lbs. N_2
35.56 lbs.

The heat produced when oxidizing of 1 pound of hydrogen is 62,000 Btu.

The third element is sulphur, having the atomic symbol S and an atomic weight of 32. The molecular weight is 64 and the molecular symbol S_2. Sulphur can either combine with two or three atoms of oxygen forming sulphur dioxide SO_2 or sulphur trioxide SO_3.

In the former case

$$S + 2O = SO_2 \text{ or}$$
$$32 + 2\,(16) = 64$$

and in the latter case

$$S + 3O = SO_3 \text{ or}$$
$$32 + 3\ (16) = 80$$

Consequently the oxygen required to burn 1 pound of sulphur to form SO_2 is 1 pound and the amount of air 4.32 pounds. The nitrogen therefore is 3.32 pounds. The weight of SO_2 formed during the combustion of 1 pound of sulphur is 2 pounds, consequently the flue gases consist of

$$\begin{array}{l} 2.00 \text{ lbs. } SO_2 \\ 3.32 \text{ lbs. } N_2 \\ \hline 5.32 \text{ lbs.} \end{array}$$

For the formation of SO_3, from 1 pound of sulphur 1.5 pounds of oxygen or 6.48 pounds of air are required, leaving 2.5 pounds of SO_3 and 4.98 pounds of N_2, or a total weight of flue gases equal 7.48 pounds.

The heat produced in burning 1 pound of sulphur to SO_2 is about 4050 Btu and to SO_3 about 5950 Btu. The heat value of sulphur is comparatively low and the quantities contained in the average coal are very small, so that sulphur really does not play an important part as a heat producing element in coal fired boilers. It might however be worth mentioning, that SO_2 and SO_3 readily combine with H_2O, forming H_2SO_3 and H_2SO_4. These products are sulphurous and sulphuric acids which, if occurring in any appreciable quantities, will do damage to any iron with which they may come into contact.

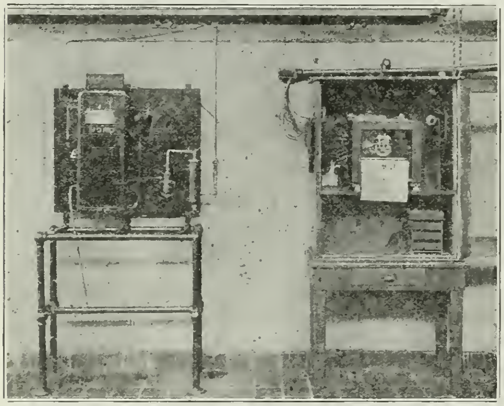


Fig. 4—Mono instruments for the gas analysis and Leeds & Northrup pyrometer for flue gas temperatures and steam temperatures.

Besides the combustible elements mentioned, there appears in coal usually a small percentage of oxygen and nitrogen. The nitrogen is useless, but has to be considered as a heat absorbing element, and therefore has to be added to the amount contained in the air, which is admitted into the furnace for combustion. With the oxygen just the reverse takes place, the amount already contained in the coal can be subtracted from that necessary for combustion.

During the practical boiler operation a certain percentage of excess air has to be admitted to insure a good mixture of oxygen with the combustibles, and to obtain complete combustion. It is the amount of excess air which gives the operator a means to judge the efficiency of combustion. For every per cent excess air which is admitted a certain amount of heat is lost, since the air has to be brought up to the furnace temperature, thus absorbing heat and carrying it away up the chimney; as a matter of fact excess air up to certain amounts increases the flue gas temperature rather than decreasing it, for the reason that air has a better heat absorbing quality than the boiler.

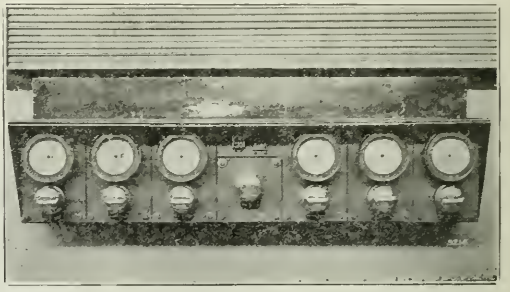


Fig. 5—Republic flow meter installation.

For every per cent of excess air admitted to the boiler furnace for the complete combustion of 1 pound of carbon

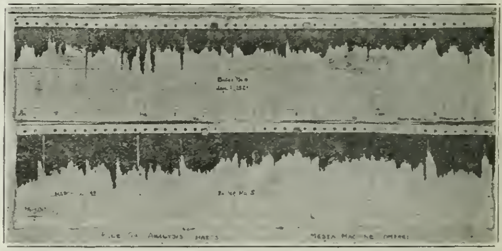
$$\frac{11.52 \times 1.0 \times 0.2315}{100} = 0.0267 \text{ pounds of } O_2$$

and

$$\frac{11.52 \times 1.0 \times 0.7685}{100} = 0.08853 \text{ pounds of } N_2$$

have to be supplied.

The total weight of flue gases for the complete combustion of 1 pound of carbon without excess air is 12.52 pounds. Assuming that the temperature of air entering the furnace is 65 degrees F., and that the flue gases leave the boiler at a temperature of 565 degrees F., and that the specific heat of the flue gases is 0.24, then the total amount of heat carried away by the flue gases is:



$$12.52 \times (565 - 65) \times 0.24 = 1502.4 \text{ Btu}$$

and since the heat value of carbon is 14,600 Btu

$$\frac{1502.4 \times 100}{14{,}600} = 12.29 \text{ per cent of the heat is lost.}$$

If now 50 per cent excess air is admitted the products of combustion are:

	Pounds
CO_2	$= 3.667$
$O_2 = 0.0267 \times 50$	$= 1.335$
$N = 8.853 + (50 \times 0.08853)$	$= 13.278$
	18.280

The heat lost now amounts to:

$$18.28 \times (565 - 65) \times 0.24 = 2194 \text{ Btu or}$$

$$\frac{2194 \times 100}{14{,}600} = 15.03 \text{ per cent}$$

Specific heat of flue gases has been mentioned, which means that for every degree F. raise in temperature of 1 pound of these gases 0.24 Btu are absorbed. Not only does the specific heat of the various substances vary, but it also varies with the temperature.

In table 1 are the foregoing combustion data, compiled:

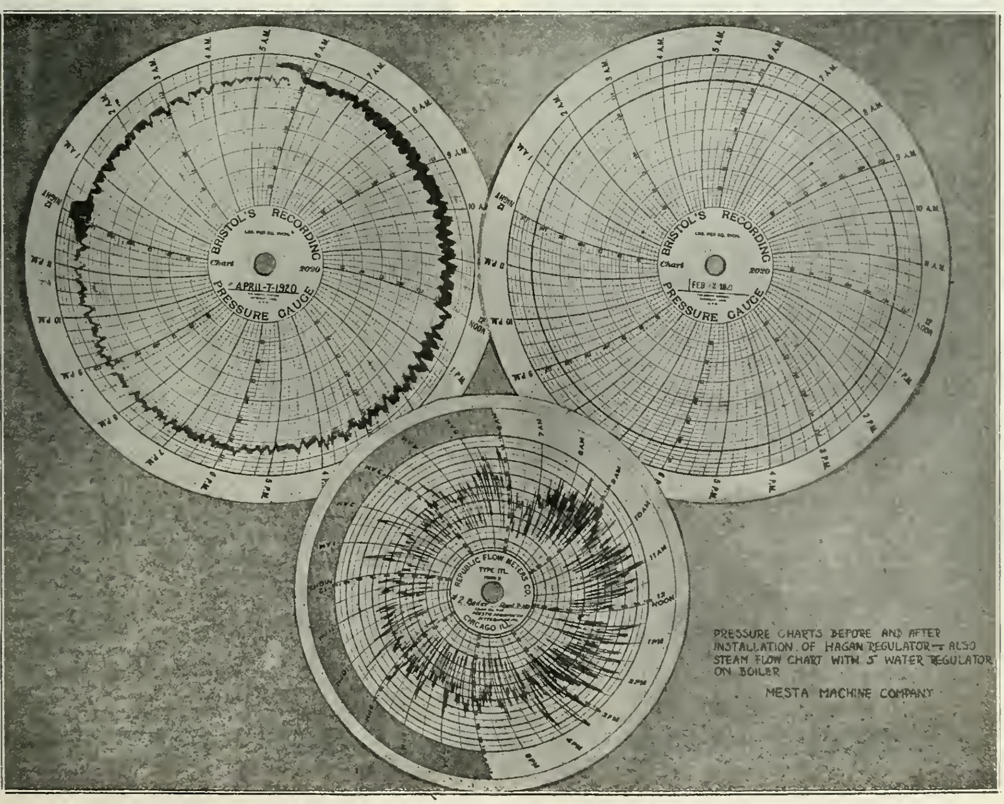
Sample	H_2	C	N_2	O_2	Ash	S	Btu
I....	4.13	61.28	1.27	8.04	23.72	1.56	11144
II....	4.54	73.42	1.57	5.21	14.08	1.18	12927

Taking two samples of different coals as fired under the boilers of the Mesta Machine Company, the various processes as outlined before can be followed.

Table I.

Tabulated data of the foregoing expressed in pounds per pound of combustible.

Substance	Heat of combustion per lbs. of combustible btu.	Atomic		Molecular		Required pounds		Weight in pounds of products of combination per pound of combustible.						Total weight lbs. of flue gas per lb. of combustible.
		Symbol	Wgt	Symbol	Wgt	Oxygen	Air	CO_2	CO	H_2O	SO_2	SO_3	N_2	
Carbon to CO_2	14,600	C	12	..	..	2.667	11.52	3.667	....	....	....	....	8.853	12.52
Carbon to CO	4,450	C	12	..	..	1.333	5.67	....	2.333	....	....	....	4.427	6.67
Carbon Monoxide	4,350		..	CO	28	0.570	2.47	1.57	....	....	....	....	1.900	3.47
Hydrogen	62,000	H	1	H_2	2	8.00	34.56	....	....	9.00	....	....	26.56	35.56
Sulphur to SO_2	4.050	S	32	S_2	64	1.00	4.32	....	....	....	2.00	....	3.32	5.32
Sulphur to SO_3	5,950	S	32	S_2	64	1.50	6.48	....	....	....	....	2.50	4.98	7.48
Oxygen	....	O	16	O_2	32	....	....	....	....	....	....	....	....	....
Nitrogen	....	N	14	N_2	28	....	....	....	....	....	....	....	....	....



PRESSURE CHARTS BEFORE AND AFTER INSTALLATION OF HAGAN REGULATOR — ALSO STEAM FLOW CHART WITH 5" WATER REGULATOR ON BOILER

MESTA MACHINE COMPANY

Products of Combustion—Sample I.

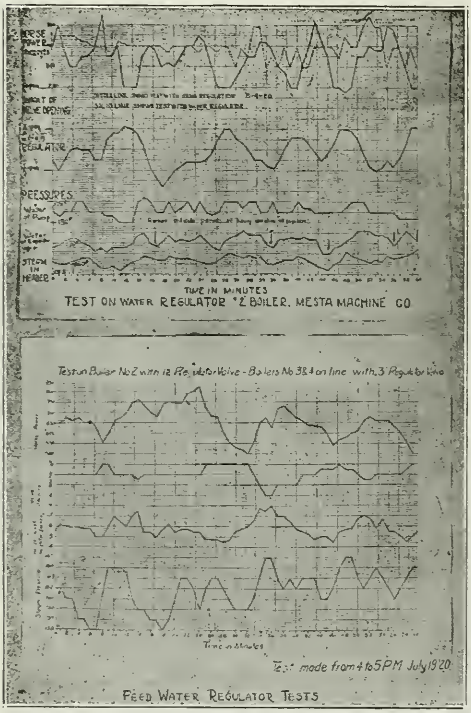
		Pounds
CO_2	$= 0.6128 + 1.6343 =$	2.2471
H_2O	$= 0.0413 + 0.3304 =$	0.3717
SO_2	$= 0.0156 + 0.0156 =$	0.0312
N_2	$=$	6.3207
		8.9707

SO_2 appears in the ordinary flue gas analysis apparatus (Orsat) as CO_2, so that the products of combustion as shown by the analysis are:

	Pounds
$CO_2 =$	2.2783
$H_2O =$	0.3717
$N_2 =$	6.3207
	8.9707

Since the total amount of air required for the complete combustion of 1 pound of coal is 8.208 pounds, for 50 per cent excess air, the weight of oxygen and nitrogen amounts to

$$8.208 \times 0.50 \times 0.2315 = 0.9500 \text{ lbs. of } O_2$$
$$8.208 \times 0.50 \times 0.7685 = 3.1540 \text{ lbs. of } N_2$$



The products of combustion with 50 per cent excess air are:

	Pounds
$CO_2 =$	2.2783
$O_2 =$	0.9500
$H_2O =$	0.3717
$N_2 =$	9.4747
	13.0747

Converting the actual weights of products of combustion for the complete combustion of 1 pound of coal without excess air and with 50.0 per cent excess air into per cent weight the following is obtained:

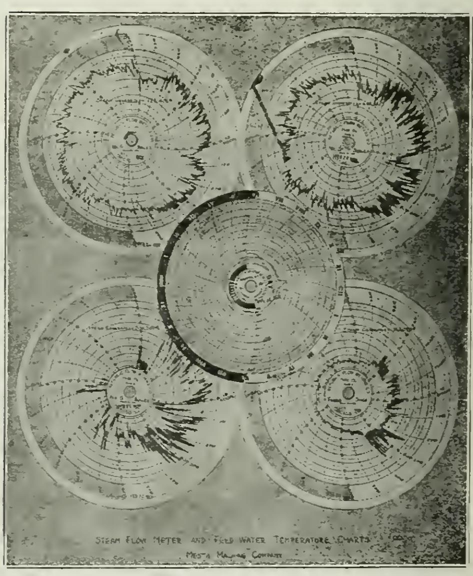
Percent Weight—Sample I.

	0.0% excess air %	50.0% excess air %
$CO_2 =$	25.398	17.425
$O_2 =$		2.843
$H_2O =$	4.143	7.266
$N_2 =$	70.459	72.466
	100.000	100.000

Since the flue gases analyzed are dry the percentage weight is:

	0.0% excess air %	50.0% excess air %
$CO_2 =$	26.495	17.936
$O_2 =$	....	7.478
$N_2 =$	73.505	74.586
	100.000	100.000

The flue gas analysis apparatus gives the percentages of the various constituents in volumes instead of in weights and the per cents weight have to be converted in per cents volume.



For converting analysis by weight into analysis by volume the molecular weights of the constituents of the gas or the densities can be used. Using the molecular weight:

0.0% Excess Air—Sample I.

	% weight	Molecular weight			% volume
CO_2	26.495	44	$\frac{26.495}{44}$	$= 0.6021$	$\frac{0.6021 \times 100}{3.2271} = 18.65$
O_2	0.000		..		
N_2	73.505	28	$\frac{73.505}{28}$	$= 2.6250$	$\frac{2.6250 \times 100}{3,2271} = 81.35$
	100.00			3.2271	100.00

50.0% Excess Air—Sample I.

	% weight	Molecular weight		% volume
CO_2	= 17.936	$\frac{17.936}{44} = 0.40763$	$\frac{0.40763 \times 100}{3.30419}$	= 12.336
O_2	= 7.478	$\frac{7.478}{32} = 0.23370$	$\frac{0.23370 \times 100}{3.30419}$	= 7.073
N_2	= 74.586	$\frac{74.586}{28} = 2.66286$	$\frac{2.66286 \times 100}{3.30419}$	= 80.591
	100.00	3.30419		100.000

Products of Combustion—Sample II.

		Pounds
CO_2	= 0.7342 + 1.9581	= 2.6923
H_2O	= 0.0454 + 0.3632	= 0.4086
SO_2	= 0.0118 + 0.0118	= 0.0236
N_2		= 7.5887
Total		=10.7131

Products of Combustion as they appear in Flue Gas Analysis.

	Weight lbs.	Weight %
CO_2	= 2.7159	25.3510
H_2O	= 0.4086	3.8140
N_2	= 7.5887	70.8350
	10.7132	100.0000

With an excess air supply of 50 per cent the following has to be added:

$$9.854 \times 0.50 \times 0.2315 = 1.1406 \text{ lbs. of } O_2$$
$$9.854 \times 0.50 \times 0.7685 = 3.7864 \text{ lbs. of } N_2$$

and the weights of the gases are

	Weight lbs.	Weight %
CO_2	= 2.7159	17.3649
O_2	= 1.1406	7.2927
H_2O	= 0.4086	2.6125
N_2	= 11.3751	72.7299
	15.6402	100.0000

It can readily be seen how important a part the air supply takes during the process of combustion, and that the air supply has to be changed to suit different qualities of coal. The proper amount of air has been supplied when the flue gas analysis shows just a trace of CO; this indicates that combustion has been complete and that the proper amount of air for the existing furnace conditions has been supplied.

In most industrial power plants steam is used for various purposes as in the case of the Mesta Machine Company, where steam is used.

1) In Mesta unaflow and Corliss engines to generate electric energy.

2) In Mesta air compressors to supply the compressed air necessary for the manufacture of the products.

3) In Mesta forging presses and steam hammers.

The demand of steam varies within wide limits and the boiler plant and boiler plant equipment has to take care of these variations without loss in economy.

To rely entirely on the human element to obtain the best results would not be good policy. The average fireman usually has no conception of the amount of money involved, his business is to make steam, to watch the steam gauge and keep the pressure up, he has not been brought up to think in Btu's. It is therefore up to the man in charge to do the thinking and operating, and as he cannot rely on the human element he has to adopt such mechanical means as suit the particular plant conditions the best. These mechanical means should enable the operating man to plan ahead rather than base today's operation on the results of yesterday. The conditions of yesterday may have been materially different from what they are today and to draw any conclusions without analyzing these conditions in detail may become a very expensive process.

The boiler plant consists of six Heine Safety Boilers, of the following specification:

Sample I.

Required for complete combustion of one pound of coal.

Products of Combustion	Oxygen pound	Nitrogen pound	Air pounds
CO_2	........................0.6128 × 2.667 = 1.6343	1.6343 × 3.32 = 5.426	1.6343 × 4.32 = 7.060
H_2O	........................0.0413 × 8.000 = 0.3304	0.3304 × 3.32 = 1.097	0.3304 × 4.32 = 1.427
SO_2	........................0.0156 × 1.000 = 0.0156	0.0156 = 3.32 = 0.052	0.0156 × 4.32 = 0.067
Total	........................1.9803	6.575	8.554
Oxygen in coal	........................0.0804		
Total oxygen required	........................1.8999		
Total air required	........................1.9 × 4.32 =		8.208
Total Nitrogen	........................(1.9 × 3.32) + 0.0127 = 6.3207		

Sample II.

Required for complete combustion of one pound of coal.

Products of Combustion	Oxygen pound	Nitrogen pound	Air pound
CO_2	0.7342 × 2.667 = 1.9581	1.9581 × 3.32 = 6.501	1.9581 × 4.32 = 8.459
H_2O	0.0454 × 8.000 = 0.3632	0.3632 × 3.32 = 1.206	0.3632 × 4.32 = 1.569
SO_2	0.0118 × 1.000 = 0.0118	0.0118 × 3.32 = 0.039	0.0118 × 4.32 = 0.051
Total	2.3331	7.746	10.079
Ogygen in coal	0.0521		
Total oxygen required	2.2810		
Total air required	2.281 × 4.32 =		9.854
Total Nitrogen	(2.281 × 3.32) + 0.0157 = 7.5887		

Number of boilers	6
Heating surface of one boiler	5450 square feet
Rated boiler horsepower	545 hp

Design of Pressure Parts.

Number of steam and water drums	2
Diameter of drums	42 inches
Length	22 feet
Thickness of plate	13/32 inches
Heads dished, thickness	½ × ⅝ inches

Manhole in rear of drums 11x15 inches, flanged-in reinforced with pressed steel covers. Longitudinal seams, double strap butt joints double riveted, girth seams lap single riveted. Water legs of flanged steel plate 17/32 inches thick, stayed with hollow staybolts and drop forged throat stay.

Tubes.

Material	Mild steel
Diameter of tubes	3½ inches
Length of tubes	18 feet
Number of tubes	315
Number of rows high	18
Number of tubes per row	17 and 18

Working and Test Pressures.

Working pressure	160 pounds per square inch
Test pressure	240 pounds per square inch

Superheaters.

Heating surface	864 square feet

Each boiler is equipped with a Westinghouse underfeed stoker of the 5-retort double dumping grate type. The specification of these stokers is as follows:

General Description.

The stokers are of the inclined underfeed type, having interlocking tuyeres for the distribution of air to fuel and provided with the necessary actuating mechanism for controlling the supply of fuel and for discharging the ash and clinker.

Stoker Equipment.

The equipment consists of the coal hoppers, unit retorts, heavy half fronts and anchor bolts, front and side observation doors, tuyeres and dumping grates.

The stokers are set in combination with six 545 hp Heine boilers, the normal rating of which is based on 10 square feet of effective heating surface per boiler hp.

Stoker Engines.

For driving the stokers, two stoker engines are provided, which can drive the stokers either jointly or separately.

Fan Equipment.

For operating six boilers at 200 per cent load, forced draft totalling 75,000 cu. ft. of air per minute at 65 degrees F. and a static pressure of 6-inch water gauge in the wind box of each stoker is required.

To operate six boilers at 290 per cent rating 134,400 cu. ft. of air per minute at 65 degrees F. are required at a static pressure of 7-inch water gauge in the wind box of each stoker.

The fan equipment consists of two No. 9 extra heavy multivane, design No. 3 Sturtevant Fans, directly coupled by means of flexible couplings to two Westinghouse variable speed motors, which latter are controlled by Westinghouse automatic starters with push button station.

The characteristic of each fan is as follows:

5-inch pressure water gauge			6-inch pressure water gauge	
Speed	Vol.	Horsepower	Vol.	Horsepower
546	39,000	52	....	..
567	43,000	62	....	..
589	47,000	72	40,100	62
631	54,600	98	48,200	86
672	62,100	125	56,300	115
715	69,700	160	63,900	145

For the control of the boilers each individual boiler is equipped with:

1) Indicating steam pressure gauge.
2) Draft gauge.
3) Republic steam flow meters consisting of
    a) One indicating instrument calibrated in horsepowers, mounted beside steam pressure gauge.
    b) One recording instrument giving the flow of steam per hour.
    c) One integrating instrument giving the flow of steam during any period.

The steam pressure of the main steam header is indicated by a pilot pressure gauge of the illuminated scale type, and one recording Bristol pressure gauge.

Coal and consequently air should be supplied to the boilers in accordance with the steam demand. This necessitates regulating the amount of coal, air and draft for exit gases frequently, if it is not done at the proper time the steam pressure will drop when the steam demand is heavy and the safety valves will blow when that demand period is over. Furthermore the pressure over the fires should be as near atmospheric pressure as possible, in order to prevent infiltration of air on the one hand, and to insure free combustion and to prevent gases blowing out of furnace doors.

After careful study of the existing operating conditions it was decided to instal the Hagan regulator to take care of the wide and sudden variations in the steam demand. The installation of the Hagan regulator proved to be a complete success, as the regulator not only regulates the fuel and air supply as well as draft conditions in accordance with steam demand, but owing to its flexibility and simplicity in operation it is possible to adjust the coal and air supply as well as draft individually or collectively to suit any variations in the quality of coal.

The steam and flue gas temperatures are recorded by a Leeds & Northrup pyrometer.

In order to control the combustion and to take care of any change in the quality of coal, indicating the time when adjustments on the Hagan regulator are necessary a Duplex Mono instrument has been installed. This was done first, to obtain a continuous flue gas record and second, to facilitate the observation of any change in operation.

The Duplex Mono instrument records the CO_2 and CO contents in the flue gases. A simple CO_2 recorder would not have been suitable for Mesta boiler house conditions, owing to the variations in the quality of coal and load. Where the composition of coal remains uniform and the furnace conditions do not change to any great extent a CO_2 recorder will prove beneficial, as a check with the Orsat apparatus at frequent intervals will soon show whether the proper amount of air is being supplied, but in cases where qualities of coal and furnace conditions change as often as in the Mesta power plant a CO_2 recorder without CO or O_2 may lead to conclusion not in accordance with actual operating conditions.

The boiler feed water is heated in an open Cochrane feed water heater. The cooling water from a 400 kw Mesta gas engine and from the Mesta air compressor is collected in a collecting tank and from there pumped to the heater, entering the heater at about 120 degrees F. The make-up cold water is admitted through a float operated valve. Exhaust steam from the Mesta engines in the power house is used for bringing the feed water up to between 200 and 210 degrees F. The amount of exhaust steam is controlled by an exhaust valve of the Cochrane multiple valve type. The exhaust steam not used in boiler feed water heater goes to heating systems of factory.

The feed water is measured by means of a Worthington hot water turbine meter.

Difficulties were experienced in the proper operation of the boilers and equipment. First, owing to the scarcity of good men, and second, owing to the great load variations. It was therefore considered advisable to eliminate the faults gradually. Steam flow meters together with a Hagan regulator were installed and the improvements in the steam pressure can be seen from the pressure charts. The flow meter charts however showed great variations which seemed to occur at practically regular intervals.

After carefully surveying these conditions it was found that the feed water regulating valves were too large, and after the installation of new regulating valves the variations in the flowmeter charts were practically done away with.

A fault common to nearly all regulating valves is the small amount of movement allowed between the closed and full open position.

A complete set of flow meter, pressure and flue gas charts are reproduced and below is given a table showing the performance of the boiler house for February 22, 1921.

Performance data for 24 hours ending February 22, 1921, Mesta Machine Company:

		Pounds
Total steam as measured by Republic flowmeters		1,668,225
Total coal	191,400	
No. 6 boiler banked 9 hours coal for banking	2,000	
Total net coal	———	189,400

Steam pressure	160 lbs. per square inch
Steam temperature	400 degrees F.
Feed water temperature	206 degrees F.
Total heat in steam	1214 Btu per lb. above 32° F.
Heat in feed water	174 Btu per lb. above 32° F.
Actual evaporation per pound of coal	8.81 lbs. of steam
Evaporation from and at 212 degrees F.	9.44 lbs. of steam

The amounts of steam as stated above do not include steam used for blowoffs, soot blowers and stoker engines.

Ratings of Boilers During Period of Steam Generation.

No. of Boiler	Horse-power	Percent rating
4	1008	185
5	892	164
6	700	128

No. 6 boiler took the peak load and consequently was banked during night. The difference in the rating of No. 4 and 5 boilers is due to the fact that the three bottom rows of tubes of No. 4 boiler were turbined on February 17, 1921.

On the Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesmann Oblique Rolling Process.

PART II.

By DR. ING. KARL GRUBER,
In Rheydt.

THE roll shown in Figs. 4, 5 and 6 is of the usual design of the Mannesmann oblique rolling mill, for the smallest pattern rolls for hollow rolling solid round bar stock of from 80 to 160 mm diameter.

The largest diameter is $D = 360$ for a body of roll of 500 mm. In addition to this size rolling mills with $D = 450$ or from 550 to 650 are made.

The working taper of length L and inclination angle δ on both sides forms an extension on the right of the largest diameter D (see Figs. 7 and 8). This working taper is of very great importance for the hollow rolling and the theoretical investigation of the rolling process is mainly concerned with this taper. The tangent of the inclination angle usually used has been $\tan \delta = \frac{1}{8}$ to 1/18.

The second factor of special importance is the oblique position of the rolls. Each one of the two rolls which are identical, is inclined at an angle $\beta =$ approximately $\pm$ 5 degrees in relation to the horizontal plane. The center lines when projected on the vertical plane therefore comprise an angle of $2\beta =$ approximately 10 degrees and intersect in the center of the roll.

The point in the center, between the two rolls, that coincides with the projection of the intersection of the roll center lines on to the vertical plane is called the center point M of the Mannesmann rolling mill. All dimensions as to length and width are determined from here and the heights are based on the horizontal plane of the center point which forms the main plane of the rolling mill.

Owing to the oblique position of the rolls, unassisted drawing-in of the bloom between the rolls and automatic feed become possible.

The bloom is not passed in the main plane of the rolling mill but, as Fig. 8 shows, in a plane by the distance h (= 40 mm for small rolling mills) higher up.

The bloom thus would be forced out in an upward direction in the rolling process but for the action of the top roll which prevents it. The latter in this way takes up part of the rolling pressure and forms the closed pass required for hollow rolling. Bottom guidance is not re-

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quired for the ordinary hollow rolling, it is however retained in view of unforeseen conditions.

The rolling in a raised plane is not connected with any particular advantage, on the contrary, the lower end of the roll has to be swivelled round to press against the bloom thus causing the center lines of the rolls to assume a warped orientation.

By raising the bloom and therefore the mandrel, the mandrel rod and the thrust bearing, a more substantial construction of the neck bearings becomes possible.

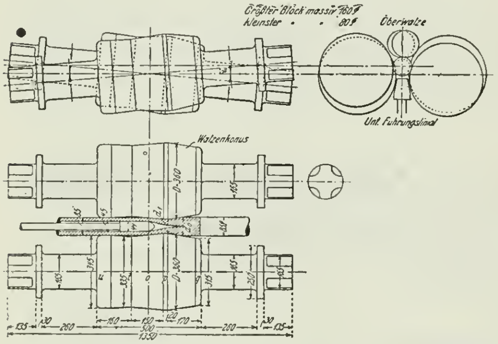
Both rolls rotate in the same direction and at identical speed. The bloom itself must rotate, if viewed in the feeding direction, from the upper towards the lower end of the rolls. In this case it is pulled into the rolls unassisted. The top roll acts as friction roll and assumes the peripheral speed of the main rolls.

Peripheral Speeds of Working Taper of Rolls and of Bloom.

A section in any position of the working tapers of equal diameter D gives a tangential peripheral speed in m per second at n rpm of:

$$v_x = D_x \pi \frac{n}{60}$$

For the same section the diameter of the bloom equals d_x and its speed n_x rpm. The diameter of the bloom diminishes in the tapered part gradually from d_0 to d_1 while the corresponding diameters of roll increase evenly from D_0 to D_1 As a consequence the speed of the bloom is increasing very rapidly from n_0 to n_1



Figs. 4 to 6.

The variable n_x can be obtained from the equation

$$\text{(compare Fig. 8a: } d_x \pi \frac{n_x}{60} = v_x \cos\beta\text{; } n_x = \frac{60\, v_x \cos\beta}{d_x \pi}$$

$$n_x = \frac{D_x}{d_x} \cos\beta\; n \qquad (1)$$

On the assumption that the feed of the bloom equals the horizontal velocity component v sin β of the roll circumference, the feed rate per revolution (compare Figs. 8a and 9) is obtained as follows:

$$s_x = \frac{v_x \sin\beta}{n_x} 60 = \frac{v_x \sin\beta}{v_x \cos\beta} d_x \pi$$

$$s_x = d_x \pi \tan\beta \qquad 2$$

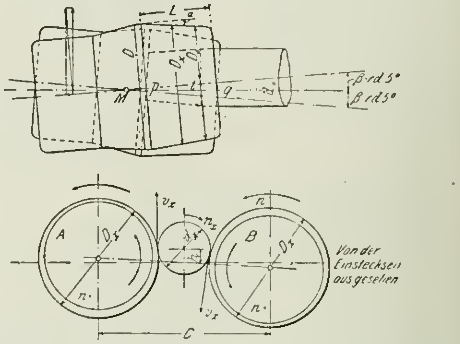
This feed rate per revolution corresponds to the pitch of the helical line on the bloom taper.

If the rolling mill is designed for a given angle β, then the pitch s_x is proportional to the diameter:

for $\beta = 4°$ or $\tan \beta = 0.07$; $s_x = 0.22\, d_x$

for $\beta = 5°$ or $\tan \beta$ 0.0875; $s_x = 0.275\, d_x$

The movement of the bloom therefore resembles that of a conical screw which is passing between the rolls with the thread being renewed all the time. As soon as the resistance of the mandrel has to be overcome by the bloom, the speed of the latter is kept up while the pitch decreases. The helical lines have a more shallow shape, and this is particularly the case when the end of the bloom enters the rolls, the hollow then being formed with difficulty only.



Figs. 7 and 8.

Mention has to be made of the fact that, owing to the position of the center line of the bloom being raised over the main center plane, small deviations as regards the movements are set up which, however, are of no practical importance. For instance, in one circular section of the bloom the circumferential speed on one side becomes smaller, by a slight amount, than that on the other side. In this instance the top roll effects on equalization, in as much as slip occurs so that an average speed is set up.

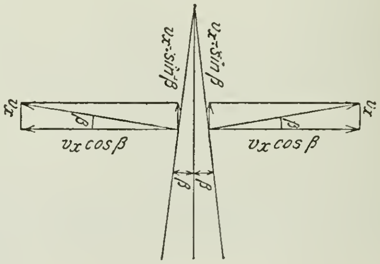


Fig. 8-A.

Torsional Angle of Cylindrical Blooms in the Working Tapers.

As soon as the solid bloom has been pulled in by the rolls, it assumes the speed n_0, as follows:

$$n_0 = \frac{D_0}{d_0} \cos\beta\; n.$$

This number of revolutions per minute is constantly increased until, with the smallest diameter d, and the largest diameter of roll D it becomes:

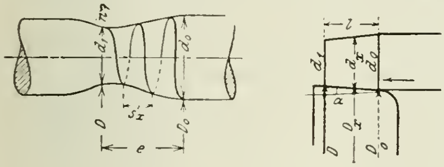
$$n_1 = \frac{D}{d_1} \cos\beta \; n$$

The number of revolutions per second increases evenly from $\frac{n_0}{60}$ to $\frac{n_1}{60}$ It follows that for each second of the rotary movement a lead of the smaller cross section takes place, as follows: $\frac{n_1 - n_0}{60}$

This lead can be expressed in angular degrees and the following angle is obtained: $\frac{n_1 - n_0}{60}$ 360 degrees.

The feed movement of the bloom, from the time of first contact to when the smallest cross section is reached, takes the time t in sec. and the angle assumes a definite value as follows:

$$\delta = \frac{n_1 - n_0}{60} \, 360 \, t \qquad (3)$$

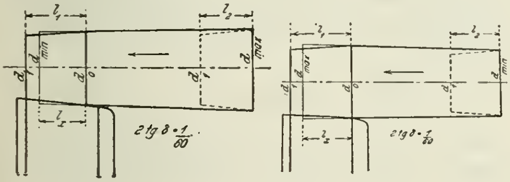


Figs. 9 and 9-A.

As long as the time t of the transition from d_0 to d_1 remains constant, the value of the torsional angle remains the same.

The torsional angle can be taken as the measure of the formation of the hollow, i.e. to a given angle δ corresponds a definite ratio formed by the inside width and the smallest diameter δ of the taper.

It therefore becomes necessary to determine more accurately the value of δ from the dimensions of the rolls and the bloom, and from the inclination angles δ and β.



Figs. 10 and 11.

For this purpose the time t has to be ascertained first. The length 1 of the bloom taper (see Fig. 9a) equals:

$$1 = \frac{D - D_0}{2 \tan \delta} = \frac{d_0 - d_1}{2 \tan \delta} \qquad (4)$$

The velocity in the lengthwise direction of the bloom, i.e. the feed rate per sec., is for any part:

$$c = v_x \sin\beta; \; c = D_x \pi \frac{n}{60} \sin\beta.$$

The increase of the velocity c therefore varies within the limits:

$$c_0 = D_0 \pi \frac{n}{60} \sin\beta; \; c_1 = D \pi \frac{n}{60} \sin\beta.$$

The average value becomes thus:

$$c = \frac{c_0 + c_1}{2} = \frac{D + D_0}{2} \pi \frac{n}{60} \sin\beta \qquad (5)$$

The time t is obtained by dividing the equations 4 and 5:

$$t = \frac{1}{c} = \frac{d_0 - d_1}{D + D_0} \cdot \frac{1}{\pi \frac{n}{60} \sin\beta \tan\delta} \qquad (6)$$

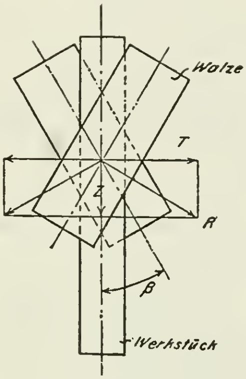


Fig. 12.

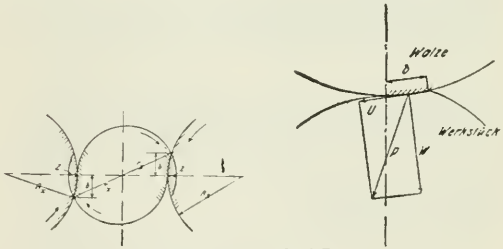
From the above equation giving n_0 and n_1 immediately follows:

$$\frac{n_1 - n_0}{60} \Big(= \frac{D}{d_1} - \frac{D_0}{d_0} \Big) \frac{n}{60} \cos\beta \qquad (7)$$

By inserting the values (6) and (7) into equation (3) the value for the torsional angle is obtained as follows:

$$\delta = \left(\frac{D - D_0}{d_1 \quad d_0} \right) \left(\frac{d_0 - d_1}{D + d_0} \right) \frac{360}{\pi \tan\beta \tan\delta} \qquad (8)$$

$$\delta = \frac{D \left(\frac{d_0 - d_1}{d_1} \right) - D_0 \frac{d_0 - d_1}{d_0}}{D + D_0} \; \frac{360}{\pi \tan\beta \tan\delta} \qquad (8)$$



Figs. 12-A and 12-B.

This equation comprises all factors which influence the torsional angle δ and consequently the formation of the hollow. The second element containing the angles δ and β is a constant for a given rolling mill.

In Mannesmann rolling mills of a roll diameter of 360 mm, the angle β usually equals 5 degrees. The angle δ, however, varies a good deal and, for instance, for δ = 4 degrees, we obtain:

$$\frac{360}{\pi \tan\beta \tan\delta} = \frac{360}{3.14 \times 0.0875 \times 0.07} = \frac{360}{0.01925}$$

and for $\delta = 7$ degrees:

$$\frac{360}{3.14 \times 0.0875 \times 0.1228} = \frac{360}{0.03377}$$

The torsional angles for these two values will therefore show a considerable difference.

The values for

$$\frac{D\left(\frac{d_0 - d_1}{d_1}\right) - D_0 \frac{d_0 - d_1}{d_0}}{D + D_0} = E;\ D = 360 \text{ mm}$$

$D - D_0 = d_0 - d_1$, so that D_0 can be ascertained; $d_0 = 80$ or 160 mm diameter of bloom.

Table 1—Clearance and Torsional Angle.

$\frac{d_0 - d_1}{d_0}$	0.05	0.10	0.15
$d_0 - d_1$	4	8	12
d_0	80	80	80
E	0.00160	0.00674	0.01600
$d_0 - d_1$	8	16	24
d_0	160	160	160
E	0.00189	0.00796	0.01887

From Table 1 can be seen that as the clearance angle of the roll increases the value E, and consequently the torsional angle increase as well.

If, through altering the clearance angle, $d_0 - d_1$ is increased to three times its value then the value of E rises to 10 times the former amount.

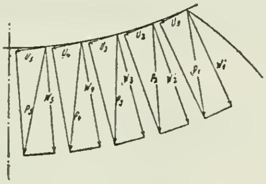


Fig. 12-C.

In rough approximation this can be stated thus: The torsional angle and consequently the formation of the hollow is increasing as the *square* of the clearance of the rolls.

This contains the essentials for controlling the hollowing process. The rolls are to be so adjusted that a sufficient hollow forms to enable the hollow bloom to be pushed over the mandrel easily while insuring a smooth interior surface. Should the mandrel offer too much resistance, then the rolls have to be set closer in order to produce a larger hollow.

Equation No. 8 is based on the assumption that the bloom is passing through the rolls without finding a resistance. If this, however, is not the case, but if the mandrel is offering a considerable resistance, the speed may be only half that shown, and the time twice as long as for a free passage. The value δ of the horizontal angle must not be changed by this. In such case the torsional angle must be set, from the beginning, to half the size.

This deviation from a free passage is particularly frequent when the end of the bloom has reached the rolls. In that case the formation of a hollow, towards the end, is impossible and the resistance of the mandrel assumes a considerable maximum value. This is a drawback of the hollow rolling process, necessitating a very marked additional amount of power towards the end of the pass of which more anon.

4. *Torsional Angle of Taper Ingots*—The previous paragraph has been dealing with the hollowing of rolled (very homogeneous) mild steel round bar of from 80 to 160 mm diameter. In addition taper ingots of from 130 to 450 mm diameter at the base and a length of from 1000 to 1200 mm are being hollow rolled. The top of the ingots is about 15 mm less in diameter. On account of this slight taper it will sometimes be difficult to strip the ingots, but the taper must be very slight as otherwise the effect on the torsional angle δ becomes very marked.

The angle δ is least for the small end of the ingot and assumes 2 to 2¼ times this value for the big end. As a consequence there will be a tendency to form an uneven hollow. At all events very considerable variations of the mandrel resistance will become noticeable.

In order to be able to shape the rolls correctly, the length of the line of contact between the ingot and the working taper of the rolls must be determined.

To begin with, the assumption shall be made that the big end of the ingot is inserted into the rolls. See Fig. 10.

If the small inclination angle between the side line of the ingot and its axis be called δ, we obtain:

$$d_0 = d_1 + 2\ l_1 \tan \delta,$$

on the other hand, the following obtains:

$$d_0 = d_{max} - 2\ l_x \tan \delta$$

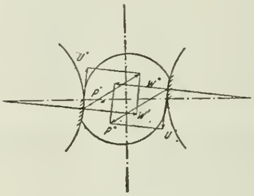


Fig. 13.

The two truncated cones of the lengths l_1 and l_x respectively possess identical volumes which under the circumstances can for the present be assumed to be $l_x = 0.9\ l_1$. From the two equations for d_0 the following is obtained:

$$l_1 = \frac{d \text{ max} - d_1}{d\ (\tan \delta + 0.9 \tan \beta)} \qquad (9)$$

This result can now be used for checking l_x more accurately. Thus we obtain for the back end of the ingot:

$$l_2 = \frac{d_{min} - d_1}{2 \tan \delta} \qquad (10)$$

For the diameter d_1 a value is selected which is large enough to provide for a diminuition of the ingot diameters of the two ends of from 0.05 to 0.15 of the corresponding diameters. From l_1 and d_1 the value for d_0 can be obtained. In this way all dimensions have been found.

Now the small end of the ingot is to be inserted into the rolls first (compare Fig. 11). Changing the signs we obtain:

$$d_0 = d_1 + 2\ l_1 \tan \delta$$

and

$$d_0 = d_{min} + 2l_x \tan \delta$$

from which, if again l_x is assumed for the present to equal 0.9 l_1 results:

$$l_1 = \frac{d_{\min} - d_1}{2\ (\tan \delta - 0.9 \tan \delta)} \qquad (11)$$

and for the big end of the ingot:

$$b_2 = \frac{d_{\max} - d_1}{2 \tan \delta} \qquad (12)$$

The value of d_1 to be taken as above when d_0 can be worked out.

Example: A round taper ingot of 450 and 430 mm diameter and 1200 mm length is to be hollow rolled. The largest diameter of roll is D = 550 mm

$$d_{\max} = 450 \text{ mm};\ d_{\min} = 430 \text{ mm}$$

$$\tan \delta = \frac{10}{1200};\ \tan \delta = \frac{1}{15};\ d_1 = 400 \text{ mm}$$

1. Big end in front: Equations (9) and (10)

$$l_1 = \frac{450 - 400}{\left(\frac{1}{15} + 0.9 \frac{1}{120}\right)} = 337.4 \text{ mm}$$

$$l_2 = \frac{430 - 400}{2 \times \frac{1}{15}} = 225 \text{ mm}$$

$$d_0 = 400 + 2 \times 337.4 \times \frac{1}{15} = 445 \text{ mm.}$$

The two values of the torsional angle δ can now be worked out as per equation (8) for $\tan \delta = \frac{1}{15}$

at the start:

$$\delta_1 = \frac{550 \times \frac{45}{400} = 505 \times \frac{45}{445}}{550 + 505} \times \frac{360}{0.01833}$$

$$\delta_1 = 0.0102 \times \frac{360}{0.01833} = 196.40$$

and at the finish:

$$\delta_2 = \frac{550 \times 30/400 - 520 \times 30/430}{550 + 520} \times \frac{360}{0.01833}$$

$$\delta_2 = 0.00467 \times \frac{360}{0.01833} = 91.7^{0}$$

2. Small end in front; equations (11) and (12)

$$l_1 = \frac{430 - 400}{2\left(\frac{1}{15} - 0.9 \times \frac{1}{120}\right)} = 253.8 \text{ mm}$$

$$l_2 = \frac{450 - 400}{2 \times \frac{1}{15}} = 375 \text{ mm}$$

$$d_0 = 400 + 2 \times 253.8 \times \frac{1}{15} = 433.8 \text{ mm}$$

The two corresponding values of the torsional angle δ are obtained in the same way as shown above:
at the start:

$$\delta = \frac{550 \times \frac{33.8}{400} - 516.2 \times \frac{33.8}{433.8}}{550 + 516.2} \times \frac{360}{0.01833}$$

$$\delta_1 = 0.00587 \times \frac{360}{0.01833} = 115.3''$$

and at the finish:

$$\delta_2 = \frac{550 \times \frac{50}{400} - 500 \times \frac{50}{450}}{550 + 500} \times \frac{360}{0.01833}$$

$$\delta_2 = 0.01257 \times \frac{360}{0.01833} = 246.9^{0}$$

The above shows in figures that the ingots behave very differently. In both cases the difference is very considerable for the two ends.

Still, probably the big end of the ingot will preferably be inserted into the rolls because pipe that may be present at the upper, small end of the ingot exerts a desirable influence on the hollow rolling in that case.

So far, in working out the tangential speeds and also the torsional angle, the slip which occurs between roll and specimen has not been considered. *The transmission of motion from the rolls to the specimen is bound to be irregular inasmuch as, through sliding friction, retardation will occur while, on account of the rolling process, in a certain sense a lead will take place. The horizontal velocity, i.e., that in a lengthwise direction of the specimen, is also influenced by the friction set up between roll and specimen through the forward travel of the molecules in the direction of the axis.* It is therefore really necessary to introduce coefficients into the calculations which take these factors into consideration; they have, however, been omitted here.

5. *Effect of Forces*—Before starting hollow rolling the rolls have to be properly set or adjusted. After the ingot has been gripped by the rolls, it is pulled through without outside assistance. The working surfaces between rolled piece and roll which we propose to call rolling surface for short are also formed unaidedly. There is further the friction R, a force which is set up by the pressure between roll and specimen and which forms a normal on the axis of the roll (see Fig. 12). This friction R acts on the specimen by its two components $T = R \cos \beta$ and $Z = R \sin \beta$.

The force, coupled with the pressure of the rolls, effects the tangential shifting of the surface molecules of the specimen which has been brought to welding heat and is in a plastic condition.

The force Z effects a shifting of the surface molecules in a direction parallel to the axis of the specimen as the roll taper resists the movement of the specimen as a whole.

The resistance of the mandrel does not figure at the beginning of the rolling period. The effect of the two forces mentioned above is to shift the molecules of the material spiral shape.

While the ingot is moving through a spiral line its diameter is decreasing. The decrease of the ingot taper, in any point of the surface, equals 2z (compare Fig. 12a).

Now, the area of the rolling surface can be worked out, as the following relation obtains:

$$2z : (d_0 - d_1) = s_x : 1$$

With s_x from equation No. 2, and assuming $l = \frac{d_0 - d_1}{2 \tan \delta}$, we obtain:

$$2z = (d_0 - d_1)\ \frac{d_x\ \pi\ \tan\beta}{\dfrac{d_0 - d_1}{2\ \tan\delta}}$$

$$z = d_x\ \pi\ \tan\delta\ \tan\beta \qquad (13)$$

This means that in a given rolling mill the decrease of diameter per revolution of the ingot is proportional to the diameter of the latter.

From Fig. 12a the rolling width b can be determined in the following way for any point on the surface:

$$z = R_x - \sqrt{R_x^2 - b^2} + r_x - \sqrt{r_x^2 - b^2}$$

$$z=R_x\left(1-\left[1-\left(\frac{b}{R_x}\right)^2\right]^{1/2}\right) + r_x\left(1-\left[1-\left(\frac{b}{r_x}\right)\right]^{1/2}\right)$$

$$z=R_x \times \frac{1\ b^2}{2\ R_x^2} + r_x \times \frac{1\ b^2}{2\ r_x^2}$$

$$z = \frac{1}{2}\ b^2 \left(\frac{1}{R_x} + \frac{1}{r_x} \right)$$

$$b = \sqrt{\frac{2z\ R_x\ r_x}{R_x + r_x}} \qquad (14)$$

After inserting the diameter, we obtain for the beginning and the end of the ingot taper:

$$b_1 = \sqrt{\frac{z_1\ D_0\ d_0}{D_0 + d_1}} \qquad (15)$$

$$b_2 = \sqrt{\frac{z_0\ D\ d_1}{D + d_1}} \qquad (16)$$

The rolling surface thus possesses an average width of $\frac{b_1 + b_2}{2}$ and a length which is equal to that of the ingot taper l.

As soon as the diameter stops decreasing, tan δ becomes 0 and therefore $z = 0$ as well.

The pressure exerted on the rolling surface then ceases.

The rolling pressure, therefore, is $W = 1 \times \frac{b + b_2}{p} \times p$.

The specific surface pressure p is dependant on the strength and the temperature of the material. In order to select a definite figure for the pressure p per sq. mm of the rolling surface, the tests of Puppet* give useful hints. From the results of experiments when passing a 2500 kg ingot through a cogging mill, the specific pressure in the plane of contact between roll and ingot can be calculated and amounts to from 4 to 13 kg per sq. mm according to the number of passes. In our case we can assume an approximate value of from 5 to 10 kg, depending on the size of the ingot and taking the lower figures for the larger, the higher figures for the smaller ingots.

The force W thus represents the pressure by which the hard roll constantly acts on the plastic material of the specimen which has been brought to welding heat.

The whole process can be compared to a hard roll rolling over a soft material in a similar way in which a wheel rolls on yielding ground.

Roll and specimen are in contact along an arc or rather part of a narabola (rolling surface), all the pressures being distributed over this length. The resultant of all the single pressures must pass through the center of neck if the latter is smooth. Its horizontal component can be obtained from the equation: $\frac{U}{W} = \frac{b/2}{R_x}$ (see Figs. 12 b and c). From this follows $U = W \frac{b}{2R_x} \times \frac{b}{2R_x}$ which represents the coefficient of the rolling friction.

This force U has to be overcome by the power drive of the rolling mill, in addition, of course, to the friction of the necks which is caused through the rolling pressure. Now, if we plot the resultant of all these forces P_1, P_2 .. P_5 on the diagram of the rolling mill, then the forces P′ and P″ form a couple which effects the rotation of the specimen round its longitudinal axis, while the transformation of the same is going on at the same time (see Fig. 13). The rolls being inclined towards each other, the forces P′ and P″ do not fall in the plane of the cross section but towards a third direction in space and can be split up into two components T′ and T″, one of which has the direction of the axis of rotation of the specimen, while the other is normal to it. The sum of the first component is marked with the letter Z in Fig. 12 and, as mentioned, causes the movement of the surface molecules of the specimen in the direction of the longitudinal axis, if the specimen itself is held back by some resistance, as in our case by the ingot taper. The sum of the second component, called T, acts on the surface normally to the axis of rotation of the specimen. The forces Z and T produce first of all the spiral shape progressive movement of the surface molecules which is transmitted to the interior of the specimen.

(Continued in May issue)

CONVENTION AND EXHIBITION OF AMERICAN SOCIETY FOR STEEL TREATING.

The board of directors has decided to hold the third annual convention and exhibition of the American Society for Steel Treating during the week of September 19 to 24, inclusive, at Indianapolis.

Before arriving at this decision, the board gave various consideration to the many invitations received. Because of the enormous size to which the exhibition has grown there are very few cities having a sufficiently large building capable of accommodating the exhibition.

Indianapolis was fortunate in having on the State Fair Grounds, the Manufacturers' Building, 360 feet in length by 220 feet in width, the total floor area of which is 76,800 square feet. The central section of this building measuring 240 feet by 100 feet, is known as the "Sunken Garden," and is 20 inches below the level of the surrounding floor space. The building is new, well lighted, and excellently adapted for exhibition purposes. The management has divided the floor space into one hundred and sixty-one 10 feet by 20 feet sections. The booths along the north wall are to be used for the live exhibits and are supplied with gas and compressed air, while arrangements have also been made for the exhibitors who require heavy electrical current to be on the promenade on the same side of the building. The floor plan was ready for distribution on March 15 and reservations can now be made.

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*Stahl und Eisen 26 V. 1910, p. 182,617.

New Controlling Valve for Open Hearths

Description of a New Type Valve for Supplying Air and Gas Mixtures to Open Hearth Furnaces, Resulting in Marked Fuel Economy and Greater Regenerative Efficiency.

By W. H. WHARTON,
Consulting Engineer, Canadian Allis-Chalmers, Ltd.

PRESENT day conditions are compelling all industrial plants to give strict attention to the questions of economy and efficiency. More especially does this apply to our large steel plants in which tremendous amounts must be continuously handled and enormous quantities of fuel of various kinds consumed in production and conversion of this material. During the last fifteen years excellent progress along these lines has been made in all steel plants, and while the results achieved might with justification be regarded as very satisfactory, there still remain many directions in which improvements might be accomplished.

There is one branch of our large steel industries which has, from a fuel economy point of view, remained almost at a standstill and is to-day in but a slightly better position than when the open-hearth method of melting steel was first introduced by Siemens and Martin. This fact is the more remarkable in the light of advancement made in almost every other branch of the steel industry.

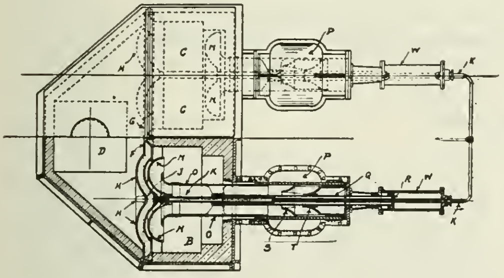


FIGURE 1

It is unnecessary to dwell in detail on the almost revolutionary changes that have been made during recent years in the coke-oven and blast-furnace practices, the very importance of which has compelled every steel man to familiarize himself with the details. The methods of rolling and handling large quantities of steel have advanced by leaps and bounds as also have the technical considerations involved in the manufacture and physical treatment of the material until a high state of efficiency and economy has been achieved, and yet, in the midst of all this advancement the fuel economy and efficiency of the open-hearth furnace has practically remained at a standstill. Some advancements have certainly been made in the preparation and production af gaseous fuel, but the actual consumption of these fuels after preparation is as wasteful as ever. The regrettable condition is probably due to several underlying causes. Possibly one of the reasons is that attention has been wholly concentrated on the metallurgical problems of open hearth practice and not without excellent results. Possibly the chief reason has been the lack of coöperation between the engineers designing open-hearth furnaces and their accessories, and the open-hearth superintendents and others, in charge of the actual operation of the furnaces, with the result that each has pursued his own course, regardless of, or oblivious to the opinions and ideas of the other.

It is pleasing to note, however, that during the past few years these prejudices have to some extent been overcome, a different attitude being demanded towards this question by the fuel stringency of recent years. As an illustration of this change of attitude, may be cited the recommendation passed at a recent meeting of the Open-Hearth Committee of the Carnegie Steel Company, one of which was to the effect that a furnace should be built apart from the rest with facilities and space to allow of the carrying out of experiments in the improvement of the ports of open-hearth furnaces, the use of removable slag pockets and the volume control of the air-supply. While each of these features demands careful and immediate consideration, it is upon the last that the greatest efforts should be concentrated. Very few of our furnace installations achieve anything near perfect combustion, in fact few exist that are using less than 50 per cent excess air. Some idea of the loss of heat units incurred may be obtained by a brief consideration of this point;

1 pound of coal forms roughly 4.34 pounds of gas. This amount of gas requires 4.86 pounds of air to form complete combustion.

Heat units (Btu) in 1 pound of coal = 12,500.

Heat units consumed in heating necessary air to temperature of melting furnace:

$$4.86 \times 3{,}000 \times .25 = 3{,}640 = 29.1\%.$$

Heat units (Btu) consumed when using 50% excess air: $729 \times 3{,}000 \times .25 = 5{,}470 = 43.7\%$, a difference representing a loss of 14.6%.

Now consider this loss in connection with the production of a 50-ton heat of steel. Under moderate furnace conditions, the consumption of coal ranges anywhere from 500 to 700 pounds per ton of steel made. Assume an average of 600 pounds. Therefore the loss on one heat of 50 tons

$$= \frac{14.6 \times 600 \times 50}{100} = 4{,}380 \text{ lbs.}$$

Annual loss on each 50-ton furnace producing 16 heats per week:

$$16 \times 52 \times 4{,}380 = 3{,}744{,}160 \text{ lbs.}$$

Now consider the cause of this loss; imperfect combustion, due to inadequate control of the incoming gases, and the use of furnace ports combined with incorrect draft arrangement which prevent, or at least

(Continued on page 280)

General View of the U. S. Naval Ordnance Plant from the right bank of the Kanawha River.

United States Naval Ordnance Plant

A Description of the New Plant Recently Constructed at Charleston, West Virginia—Engineering Features of the Open Hearth in Detail.

By **WILLIAM J. PRIESTLEY,**
Steel Superintendent.

PART I.

THE earliest recorded suggestion for armor for fighting ships seems to have been made in 1805 by Sir William Congreve, an Englishman.

Records show that in 1812, an American by the name of John Stevens of New Jersey, submitted to Congress, plans for an iron clad vessel. Nothing definite, however, seems to have resulted from this proposal until 1841, when it was determined by actual experiment the thickness of wrought iron required to resist the attack of the projectiles then in use.

The first floating batteries were laid down by the United States, England, and France in about 1854.

The earliest armor used was made of wrought iron, sometimes of single thickness and frequently in successive layers of wood or concrete. As time went on, improvements were made in the penetrating qualities of projectiles, and steel instead of wrought iron was used to procure the necessary increased resistance. The race between the armor plate-maker and the armor piercing projectile-maker had now started and has continued for more than half a century.

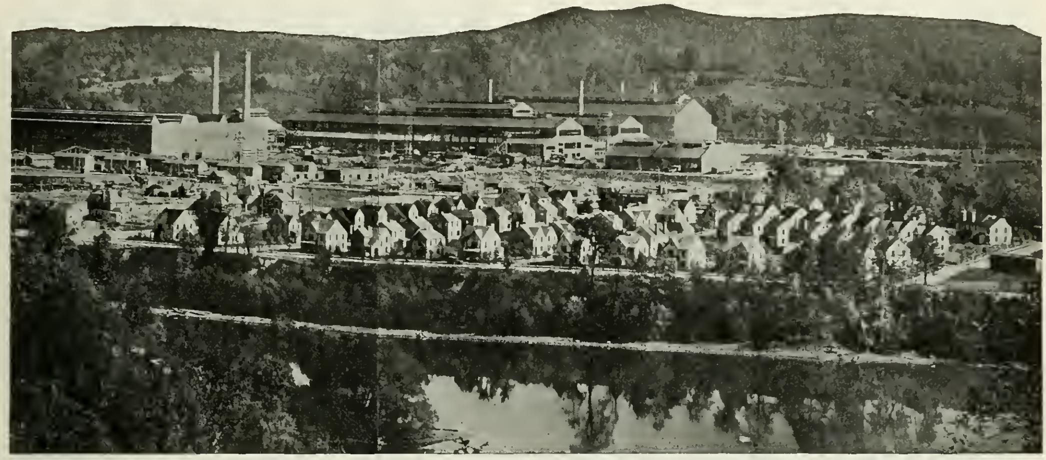
The Bethlehem Iron Company commenced the manufacture of armor in 1888. Harvey armor, which consisted of cementing and subsequently hardening one face of a nickel steel plate, was introduced in 1891. With the development of the capped projectile, armor plate offering greater resistance than that produced by the Harvey process had to be developed.

In 1898, the Krupp process of making armor plate was introduced into this country. It was found that by the introduction of chromium into the steel along with the nickel, a tougher back and stronger face might be produced. Since that time, various modifications have been made in chemical analysis, method of forging, heat treatment and physical properties of armor plate, but no marked change had been made in all these years in the method of melting or making the steel of the high quality that is necessary for ordnance material.

This fact was never forcibly brought home to the many steel-makers of the country until the war, when scores of plants were turned over to the government, for the manufacture of gun forgings, projectiles, and other ordnance material. In the building of battleships and ordnance material, where every surplus pound of material used is an impediment in action, the best quality of steel is paramount.

At the present time, the armor piercing projectile has a decided advantage over the armor plate. Steel manufacturers have always looked upon the ordnance branch of their business as "hazardous," and consequently, have not been inclined to expend the same amount of money in experiment as in other branches of their business. The Navy department has long been aware of this situation and this was one of the principal reasons for building a Steel Plant of its own where standards of quality could be set, without restraint of the problems confronting private manufacturers.

The advent of the electric melting furnace, with its greater flexibility of operation over the basic and acid open-hearth furnaces, seemed to offer a starting point



Kanawha River in the foreground; C. & O. R. R. in the background at the foot of the hill.

for the higher grade product desired by the Navy. The accuracy of this assumption has already been proven after the first year of operation of a navy owned plant. At the present writing, the navy operated plant at South Charleston, West Virginia, has made 16-inch armor piercing projectiles, torpedo air flasks and gun forgings which have surpassed all tests made by private manufacturers.

Location and Facilities.

The United States naval ordnance plant is located on the left bank of the Great Kanawha River, about five miles west of the city of Charleston, and also on the main line of the Chesapeake & Ohio Railroad. Situated in the very center of the great bituminous coal, natural gas, and oil fields of West Virginia, the plant possesses many advantages for economical operation with which most steel plants are not favored. The proximity of the plant to the base of refractories in Kentucky and Ohio also afford it various advantages.

The government reservation covers approximately 200 acres and is divided into two Units. The North Unit, built in 1918, is laid out and equipped for the manufacture of large caliber armor piercing projectiles, gun forgings up to and including 6-inch bore, 21-inch torpedo air flasks, ship shafting, armor plate bolts and nuts, and miscellaneous battleship and mount forgings. The South Unit, built in 1919 and 1920, is laid out and equipped to make battleship armor plate and large caliber gun forgings up to 20-inch bore.

Source of Power.

The electric power used for operation of the plant is at present supplied from two sources. The West Virginia Water & Electric Co. of Charleston supplies the North Unit with 5,000 kw at 2200 volts. The Virginian Power Company of Cabin Creek, supplies 22,000 kw additional power for the South Unit. The latter is delivered over two high tension transmission lines at 66.000 and 44.000 volts, from a coal-operated plant, in the heart of the bituminous coal fields, about fifteen miles up the Great Kanawha River. Located at this place is a 20,000 kw generator, with 7460 hp Babcock-Wilcox boilers, originally installed by the government during the war for furnishing power to the large powder plant at Nitro. This has come into the possession of the navy for use in operating the Naval ordnance plant at South Charleston.

Fuel.

One of the economic reasons for locating the plant in West Virginia, was the advantage of using natural gas as a fuel. The total requirements for operating both North and South Units amount to approximately 6,000,000 cubic feet of gas per day. This natural gas is furnished by the Charleston-Dunbar Natural Gas Company. The navy has first call on 15,000 acres of proven territory in Kanawha, Putman, and Logan counties. The gas, which has a calorific value of 950 to 1000 Btu is received at about 50 pounds pressure through an 8-inch pipe line.

At the present time, coal is used principally in the boiler plant and yard locomotives. This is delivered from local fields over the Chesapeake & Ohio Railroad. At a later date, when it may become necessary to resort to artificial gas for firing the furnaces, coal used for this purpose may be unloaded from barges on the Kanawha river. The consumption of coal at this time does not warrant the erection of a dock or unloading wharf.

Water Supply.

The plant has two sources of water supply. A pump house has been erected on the Kanawha river for taking care of cooling water for furnaces and fire protection. This consists of two 2,000 gallon per minute centrifugal pumps which deliver water through a 30-inch tile pipe embedded in concrete to a large settling basin of about 25.000.000 gallon capacity. As the plant uses about 5,000.000 gallons per day for cooling purposes, this provides for a five-day's reserve of clear settled water. From the settling basin the water is delivered to a large standpipe 24 feet in diameter and 120 feet high, containing 400.000 gallons. This tank is made of 1-inch plates at the bottom, ¼-inch plates at the top. In case of emergency, the water in the standpipe alone would accommodate the cooling equipment on the furnaces four or five hours. The West Virginia Water & Electric Co. furnishes 375,000 gallons per day for domestic purposes and emergency storage in case of fire or breakdown of the other system owned and operated by the ordnance plant. A small distillation plant has been erected for supplying drinking water.

Description of Manufacturing Equipment.

Having mentioned in a general way the purpose of the plant and its service utilities, it is now proposed to present to the reader, a more detailed description, than has heretofore been published, of the equipment and apparatus used in the making of the large and heavy ordnance material enumerated in the introductory paragraphs. It is not proposed to enter into the processes or methods of making armor plate, guns or projectiles, at this time.

Therefore, the equipment used in making and heat-treating the steel will be described not in the sequence used for any particular article, but will be divided under the three groups, as follows:

Melt Shops—Number One, Number Two.
Forge Shops—Number One, Number Two.
Heat Treatment Shops—Number One, Number Two, Number Three, Number Four.

Melt Shop No. 1.

Melt Shop No. 1, in the North Unit, is located in the west end of the Forge and Foundry building, which is about 130 feet wide and 560 feet long. The main bay is 75 feet wide and is served by two overhead traveling cranes, 35 and 20 ton respectively. The former has a 5-ton auxiliary hoist.

At present, there are three 6-ton basic standard type Heroult electric melting furnaces in this shop, melting cold scrap salvaged from other navy yards and stations. The furnaces operate with alternating current of 110 volts, which is stepped down from 2200 volts through a separate transformer of 1500 kva capacity on each furnace. The furnaces are equipped with Thury regulators for operating the 17-inch amorphous carbon electrodes. Roof rings, electrode holders and skewbacks are water cooled.

The furnaces are hand charged with cold scrap, which is delivered on scales from the stockyard, parallel to and north of the melt shop. The accompanying photograph, Fig. 8, taken from the east end of the stockyard, shows the arrangement of bins, method of handling scrap with electric magnet and 5-ton overhead traveling crane, and means of loading on scales placed on a transfer car. Note how carefully scrap, turnings, and raw materials are segregated, and method of labeling bins. This careful segregation of carbon, nickel, and nickel chrome, scrap and other raw materials, is a practice that will repay any melt shop working on various grades of alloy steels.

The charging floor is elevated 12 feet above the ground level. This offers greater ease in slagging off, and caring for the furnace mechanism, than if the furnaces were in pits in the ground.

Steel for 16-inch armor piercing projectiles, 6-inch gun forgings, 21-inch torpedo air flasks, 16-inch mount counter recoil cylinders, is melted in the three 6-ton furnaces and cast into ingots weighing, 1, 3, 6, 12 and 18 tons each. Steel castings for construction of the South Unit were made here; also, all castings for repairs and maintenance.

Steel is cast in iron molds, placed in a pouring pit 7 feet wide, 24 feet long and 14 feet deep. Two to three heats per furnace from cold scrap are made in 24 hours, using about 900 kwh per ton of steel produced. 17-inch amorphous carbon electrodes are used with a consumption of about 36 pounds per ton of cold scrap melted.

As quality is more important than quantity on high grade ordnance steel, the furnace men are encouraged to be most particular with their melting practice. Special attention is paid to the temperature at which the steel is placed in the molds. The regularity of this practice is evidenced by the long life of roofs and side walls. It is customary to get from 115 to 125 heats from the lining and roof of a furnace without patching during the campaign. This is on cold melting. A very close record of each heat is kept so that reference may be made at any time after forging or heat treatment, and results verified if anything out of the ordinary occurs in final tests. This is a system that every steel plant could well afford to adopt.

Iron Foundry.

In this same building, two 60-inch Whiting cupolas, are located east of the electric furnaces. These are used for making ingot molds, dies, jig and furnace castings, etc. for the rest of the plant.

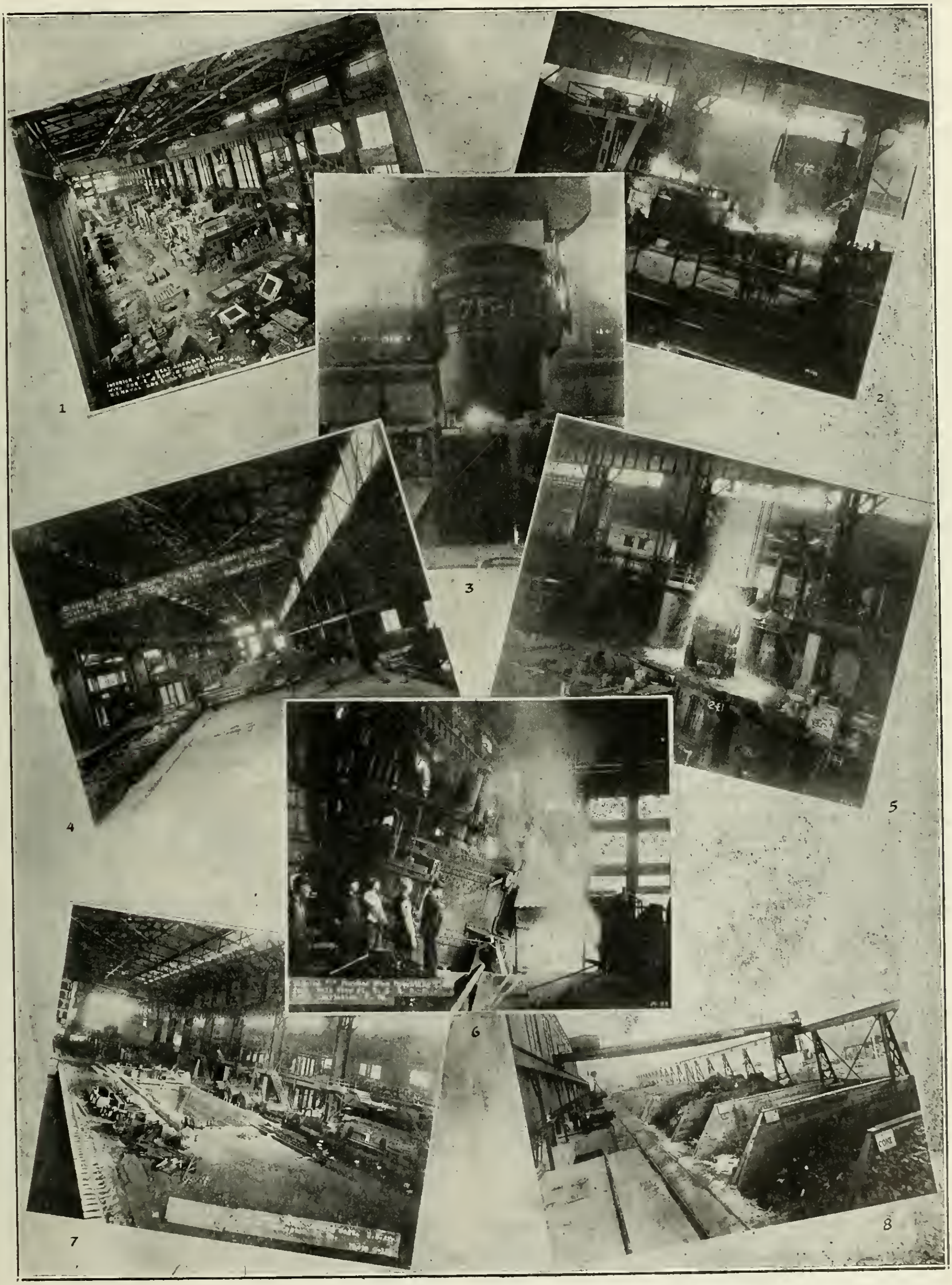
The photographs, shown of the U. S. Naval Ordnance Plant, on the next page are descriptive of the following:

Fig. 1—Interior view of Melt Shop No. 1. showing 6-ton Electric Furnaces in middle of picture.
Fig. 2—First heat of steel being poured into 40-ton electric for refining.
Fig. 3—First armor plate ingot being cast — Note, method of bridging large casting pit around ingot mold.
Fig. 4—Charging Floor of Melt Shop No. 2. Storage bins for raw materials in the distance.
Fig. 5—First heat of steel being tapped from open hearth furnace.
Fig. 6—View of 6-ton Electric Furnace being tapped.
Fig. 7—View of Pouring Aisle in Melt Shop No. 2. Open hearth furnaces in middle of picture. 40-ton Electrics to the left of the picture, behind transformer house.
Fig. 8—View of stockyard. North of No. 1 Melt Shop. Note—arrangement of bins for segregation of raw materials.

Brass Foundry.

A small brass foundry consisting of two 300-pound tilting natural gas fired furnaces, supply metal for bearings, bushings, valve seats, etc. for the other departments of the plant. Two large natural gas fired carbottom drying ovens 32 feet long by 10 feet wide by 8 feet high are used for drying cores and sand molds.

A one-ton Heroult electric melting furnace located west of the three 6-ton furnaces on the same charging floor level is used for remelting tool steel salvaged from other navy yards and stations. This furnace is also used for making experimental heats of steel with new alloys before making larger heats in the 6-ton and 30-ton furnaces. It is contemplated to install sometime in the future, a small motor-driven rolling mill for finishing tool steel.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Melt Shop No. 2.

Melt Shop No. 2 at the extreme south side of the South Unit, running east and west and parallel with the Chesapeake & Ohio Railroad tracks. It covers altogether 331 feet by 516 feet. It is made up lengthwise of twelve bays each 43 feet long. The pouring bay is 107 feet wide, the charging bay is 86 feet, the leanto 32 feet and the stockyard 106 feet wide. The charging floor is 17 feet above the ground of the pouring bay. The charging floor extends 30 feet, beyond the building line into the stockyard, thus forming an elevated charging platform. This contains two parallel tracks and track scales, so that if desired, charges may be made up directly from the stockyard scrap pile by means of electric magnet and 15-ton overhead traveling crane. The accompanying photograph, Fig. 4, shows charging bogies on tracks described above, in process of being loaded. harges may also be made upon the ground level and delivered to the charging floor over the scales by way of an inclined trestle at the east end of the platform.

Melt Shop No. 2 is served by six cranes, described by the table below:

Location	Pouring Side			Charging Side	Stock Yard	
Crane Number	1	2	3	4	5	6
Make	Morgan	Morgan	Morgan	Shaw	Shaw	Shaw
Type	2-gird. hook	4-gird. ladle	4-gird. ladle	2-gird. hook	2-gird. hook	2-gird. hook
Capacity— Main Host	250	125	75	25	15	15
Capacity— Auxiliary hoist ..	40	25	15	10	..	..
Speed per min. aux.	20	23	30	30	..	..
Speed per minute— Bridge	200	200	200	250	300	300
Speed per minute— Trolley	75	75	100	150	150	150
Speed-main hoist ..	10	10	14	23	50	50

At the present time, there are two 75-ton basic open-hearth furnaces, and two 40-ton basic electric melting furnaces in No. 2 Melt Shop. Pig iron and scrap are melted down in the open-hearth furnaces and transferred to the electric furnaces for refining and finishing. Provision is made for the addition of one more 75-ton open-hearth furnace west of the two now installed.

It is proposed to re-erect in the South Unit (Melt Shop No. 2), two of the 6-ton furnaces now located in Melt Shop No. 1. These small furnaces will be used for melting down cold nickel chrome scrap for projectiles and smaller ordnance forgings. This will concentrate the melting of all the high-grade ordnance steel into one building with minimum overhead expense and maximum supervision. The use of the electric furnace in melting steel of this kind results in the recovery of considerable chromium which would be lost by oxidation if the melting were done in an open-hearth furnace. The reducing atmosphere of the electric furnace enables practically all the chromium present to be recovered.

Steel for armor plate, large and small guns, projectiles, etc. is both bottom and top poured into heavy iron molds, provided with brick and sand hot tops. Variation of the above methods of pouring depends upon the class of work in hand.

It may be possible, after a long period of running, if so desired, to convert one of the basic open-hearth furnaces to an acid furnace, and cast the steel directly without duplexing, as the discard from the electric steel ingots is high-grade scrap—very low in both phosphorus and sulphur. Molten steel taken from the open-hearth for duplexing has shown phosphorus as low as .009 and sulphur as low as .015. On a heat of this kind made from electric furnace scrap, very little work has to be done in the electric furnace, except deoxidizing, making necessary addition of alloys and obtaining proper temperature before casting into ingots.

After duplexing through the electric furnace, ordnance steels are showing final analysis as low as .009 phosphorus and .006 sulphur. With this almost complete elimination of phosphorus and sulphur, in duplexing from the basic open-hearth through the basic electric furnace, it would be possible to use pig iron and scrap of much higher phosphorus and sulphur content than is ordinarily required for acid open-hearth and direct basic open-hearth practice.

In the design of the open-hearth furnaces by the naval ordnance plant, a study was made of dimensions and proportions of at least ten (10) successful operating furnaces. They were built under contract by William Swindell & Bros. of Pittsburgh. The portions of the open-hearth furnaces are as follows:

HEARTH—

Length	36 ft.
Width..........................	14 ft.
Area in square feet...............	504 ft.
Area in square feet per ton........	6.72 ft.
Height of roof above door sills...	7′ x 4″

REGENERATORS—Air only

Length	25 ft.
Height..........................	13 ft.
Width..........................	14 ft.
Checker volume..................	4550
Cubic feet per ton................	60.7
Air uptake square inch............	2809
One stack on each furance........	6′ x 150′

HEARTH ROOF—

Thickness..........................	12″
Skewback—above foreplate........	5′ 11″
Charging doors—center............	4′ 6″ x 4′ 6″
2 doors..........	3′ 6″ x 3′ 6″
2 doors..........	3′ 6″ x 3′
Spring (roof)......................	17″
Port Area..........................	34″ x 6′ 10½″

Blaw-Knox water-cooled doors, frames, buckstays and valves.

Cooling water consumption—25-pound pressure 150,000 gallons per 24 hours.

Natural gas consumption—about 1,000,000 cubic feet per day—btu in gas 950 to 1000.

The gas is fed on both sides of the ports through a 4-inch pipe under 8 to 12 ounce pressure.

The open-hearth furnaces are served by one standard 5-ton low type "Wellman-Seaver-Morgan" charging machine designed for handling 7-foot boxes. Principal dimensions of machine are as follows:

Span C. to C. track wheels......................	24′ 6″
Wheel base of machine..........................	16′ 3″
Maximum stroke of ram.........................	19′ 0″
Maximum lift at end of ram......................	2′ 6″
Speeds—under full load:	
Hoist..........................	18 to 20 strokes per min.
Twist of ram..........................	20 to 25 R. P. M.
Cross travel of trolley..............	150 to 200 ft. per min.
Longitudinal travel of machine......	350 to 400 ft. per min.

Charging bogies carry four 5-ton boxes. Bogies have plate steel tops. Charging boxes are steel castings made at the naval ordnance plant. The hot metal ladles were designed at this plant and furnished on contract by the Treadwell Engineering Company. Ladles are 40-ton, 75-ton, and 100-ton capacity, provided with adjustable yoke type stopper rigging. A side dump cinder car of 200 cubic feet capacity is used for handling slag as it overflows from the ladle.

A large pouring pit 30 feet wide and 150 feet long was built for teeming large ingots. A portion of the pit is 16 feet deep, the balance 8 feet. This also serves for burying and slowly cooling ingots in ashes.

At the east of the building, in line with the charging floor, are ten large bins built for storage of raw materials, under cover of the main roof of the building. Material from these bins is lifted by means of a single line grab bucket—hung on the overhead traveling crane and placed wherever desired without double handling. Each open-hearth furnace has five doors electrically operated from a central station by "Shepherd" hoists of 2 tons capacity. The tapping spouts are steel castings and are handled by means of 5-ton Jib cranes 25 feet effective radius, attached to the building columns in front of the furnace.

A well equipped "quick test laboratory" is located midway between the open-hearth and electric furnaces. A storeroom containing miscellaneous supplies likely to be needed in case of emergency, has been located at one end of the building on the charging floor. Office for foreman and clerks is also located on the charging floor close to electric furnaces where the steel is finished. Well equipped lavatories, showers, and locker room are provided for the workmen.

40-Ton Electric Furnaces.

Two 40-ton electric furnaces are located well out in the pouring bay, east of the open-hearth furnaces. A spacious platform has been provided around the furnaces on the same level as the charging floor of the open-hearths. The electric furnaces are four-door Heroult type, basic lined, and may be briefly described as follows:

Diameter of steel shell unlined........	18 ft.
Height of steel shell unlined..........	8 ft.
Thickness of brick walls..............	18" with 1½" sand between brick and furnace shell.

They operate on a 3-phase, 60-cycle circuit, at 90, and 110 volts. Power is received through a 3300 kva water-cooled transformer, from a 6600 volt primary circuit. Each transformer is located on the charging floor directly behind the furnace, which it supplies with power. At the present time, 24-inch amorphous carbon electrodes are being used. These are operated by "G. E." regulators, equipped with 5 hp motors for raising and lowering. Provision is also being made for the use of 14-inch graphitic electrodes.

In tilting, the furnace rolls on eight (8) large spools instead of tilting about trunnions as in the case of smaller furnaces of the same make. A circular base casting on the furnace rests upon the eight large steel spools and is rocked by means of a large driving gear operated by a 35 hp, 230 volt tilting motor with brake. These are the largest electric furnaces built to date. The furnaces are equipped with water-cooled doors, frames, skewback, electrode holders, roof rings and current conducting electrode arms. After much thought, the furnaces were placed so that both would tap in the same direction into the pouring bay instead of towards each other. Large tilting platforms were placed in front of each furnace. These are in one piece and open away from each other so as not to obstruct the view of the craneman or operator on the melting floor during tapping. The platforms are operated by electric motors and a series of drums and cable.

With the equipment provided, it is possible to make individual ingots up to 175 tons in weight. This is the maximum weight required for present day armor plate or gun forgings. In the development of high-grade alloy steels, containing manganese, silicon, chromium, molybdenum, zirconium, vandium, tungsten, titanium, and other rare metals, the electric melting furnace has enabled steel-makers to accomplish much which could not be done in either the acid or basic open-hearth furnace. Besides eliminating to almost a trace objectionable elements like phosphorus and sulphur, the electric furnace with its reducing atmosphere enables the rarer elements mentioned above to be alloyed with the iron in the furnace, and not left to the uncertainty and non-uniformity resulting from adding them in the ladle.

Furthermore, chemical composition, and temperature control may be more carefully regulated in the electric furnace than in the open-hearth. Electric steel may be more nearly de-oxidized before leaving the furnace by proper working of the bath and slag, than can be accomplished by the addition of the most vigorous deoxidizers. Too liberal use of deoxidizers like manganese, silicon, or aluminum, or titanium, in the ladle or mold, are very apt to fill the steel with non-metallic inclusions which injure its use for ordnance purposes.

It is in this respect as was stated in the beginning of this article, that the electric furnace with its greater flexibility of operation seems to offer a more positive means of procuring the necessary higher grade of steel for armor plate, large guns, and projectiles, than could be obtained in the open-hearth furnace. The uniformity and lower rejections of forgings due to "off composition," slag and other impurities, more than offsets the increased cost of the electric steel ingots.

ENGINEERS IN PUBLIC LIFE.

The American Engineering Council of the Federated American Engineering Societies has sent to President Harding a communication asking that an engineer be appointed Assistant Secretary of War. Another communication requested Mr. Harding to name an engineer for the vacancy on the Interstate Commerce Commission.

The appeal to President Harding to select an engineer as Assistant Secretary of War states that this position is one requiring "very special qualifications a large part of which are concerned with engineering."

In requesting the President "to give earnest thought to the selection for the Interstate Commerce Commission of a man whom to his other qualifications adds the training and experience of an engineer familiar with transportation problems," the communication sent by Chairman Channing, says:

"The transportation systems of our country are largely the creations of its professional engineers. This statement can be made without disparagement to the statesmen, the mechanics, the laborers and many others who, with the engineers, have contributed to the development of transportation."

Scullin Steel Company's New Mills

New Features Not Common to Rolling Mills Are Used in the New Scullin Steel Company Installations at St. Louis.

By F. B. MENNER,
Manager, Mill Department.

AMONG the new steel mills put into operation during the past year, that of Scullin Steel Company, St. Louis, Mo., modern in all its facilities, presents some new and interesting features heretofore not common in rolling mills.

The mills were installed adjacent to the Company's large open-hearth foundry plant, and designed to take care of two-thirds of the tonnage from their twelve 35-ton, basic open-hearth furnaces; the remainder, or some 6,000 tons being used for steel castings of which the Scullin Company is one of, if not the largest producer in the country, having devoted over twenty years to manufacturing railroad specialties, castings for sugar mill and mining machinery, and similar work.

The installation is designed to economically produce wide range of billets, merchant bar and structural shapes which the central and southwestern markets demand, and up to the high standard that has been established as Scullin quality. The mills in operation at present consist of a 4-stand, 3-high, 22-inch mechanical mill, and a 12-inch Belgian mill of 5 stands, preceded by a 16-inch mill for roughing. Plans are under way for an 8-inch mill to take care of the small sections economically produced in hand mills. All standard sizes are being rolled. Rounds and squares up to 6-inch, flats to 7-inch wide, angles to 6 x 6-inch, and beams and channels to 8 x 10-inch, in addition to a number of specials which the Scullin Company have developed.

The steel is transferred from the open-hearth by the Company's interplant railroad, in the form of 12 x 12-inch, 10 x 10-inch and 8 x 8-inch ingots, which are charged cold into an oil fired continuous heating furnace. This furnace was constructed by the Scullin organization, all patterns and castings being made in their foundry department. It is of the flat arch, water-cooled type, the hearth being 15 feet x 46 feet 3 inches. The ingots are transferred from cars by cranes, to a skid table from which they are delivered by roller line to an electrically operated, rack and pinion ingot charger, which pushes them through the furnace in double rows on water-cooled skid pipes. Preheated air for the eight Anthony oil burners used, is supplied from tempering chambers built in the roof of the structure. Furnace capacity is between 25 and 30, 12 by 12-inch ingots an hour, or approximately 27 tons.

The fuel oil is pumped from the Company's large storage in the foundry department, two-third of a mile away, to a 20,000 gallon concrete secondary tank adjacent to the mill buildings, from which two motor-driven triplex Gould pumps circulate the oil, the consumption being checked by means of oil meters at each furnace.

The furnace has an end discharge and delivers ingots to a table which is provided with hydraulic ingot turner to handle tapered ingots.

22-Inch Mill.

The 22-inch mill has four stands of three-high rolls, with enclosed pinion housings. The first, or what would ordinarily be a roughing stand is unusual in that it is identical with a three-high blooming mill in its operation. The center roll is, however, balanced and operated up and down by hydraulic cylinders, the top roll being raised and lowered by motor-driven screwdown. The rolls are turned with one bull head and five box passes, giving a range of popular size billets from 3 to 8 inches. During roll changes, and such other time as is required, ingots are rolled into billets for use in the small mills and outside shipment. Since only 15 minutes are required to uncouple the remaining three stands, this combination mill is made a constant tonnage producer and a unit most satisfactory from a mechanical and economical standpoint.

Two, 30-inch hydraulic up-cut shears are located on runout tables on the up-and-down side of the blooming stand, for end cropping and billet shearing. These together with a motor-driven shear gage, hydraulic pusher, and an electrically operated billet conveyor, delivering billets to the central storage yard, comprise the billet handling equipment.

For the main mill drive, an 1800 hp induction motor, operating on 2200 volts, has been provided by Westinghouse Company. Its speed of 366 rpm is reduced to mill speed of 68.6 rpm, by double helical gear set; on the pinion shaft are overhung two 9-inch cast steel fly wheels, weighing 27,000 pounds each.

Four traveling and tilting tables deliver the material to the passes of the various stands with the aid of pull-overs on the transfers, back and front of the mill. Each table is operated by Westinghouse motors of 80, 60 and 30 hp respectively.

A sliding frame hot saw is provided on the finishing stand runout table.

One hot bed, 65 feet long, and equipped with upenders, pullover channels and dogs, has been installed at the present time, with provision for a second after mill tonnage is built up.

The finishing end has a motor-driven roller straightener for structural shapes, which is pulled in and out of position with the hot bed delivery and shear approach table transfer as is required. Two motor-driven vertical shears are served by roller tables and transfers, and sheared material is dumped into the cradles ready for inspection, weighing and shipping.

The shipping facilities include a 20-ton Fairbanks scale and trackage in the building for five standard cars.

A 15-ton crane has been provided for handling finished material and a five motor, 45-ton crane of sufficient capacity to transfer the complete housing with its roll and guide equipment, to save time in roll changing.

Roller tables, hot bed and other mill auxiliaries are driven by Westinghouse mill type motors, of which over 100 have been furnished. These are operated by master switches and magnetic control panels, installed on five operating stations along the sides of the building, thus permitting the operation of the mill to its full tonnage with a very small force of men.

12-Inch Mill.

Billets for the 12-inch mill, of 3 x 3-inch and 4 x 4-inch sizes are handled from stock piles by one of the two 5-ton electric cranes in the storage yard, weighed and transferred to billet platform for the 12-inch mill furnace, from which they are fed in pairs on a motor-driven roller chain conveyor to a pusher at the charging end. Stops are provided for charging one, two and three rows for economy in heating. The furnace pusher is a duplicate of the one installed at the 22-inch mill furnace, and the furnace for the small mill is identical in design with the one described above, but with reduced dimensions; the hearth being 9 x 37 feet. Four burners are used and the billets are pushed through on seven skid pipes.

The five stand, 12-inch mill, with its one stand of 16-inch roughing rolls, is a typical Belgian mill installation. A motor-driven vertical shear for cutting long billets to be rolled into smaller sections has been installed on a roller line between the two mills, and a spacious iron plate floor on both sides of the mill provides ample room for running out bars during rolling.

A mechanical hot bed of the ratchet and shuffle bar type handles all material from the 12-inch mill. This is one of the first of its kind built by the United Engineering & Foundry Co., who built the mills and furnished most of the other mill equipment. The bed will handle bars up to 110 feet in length, discharging automatically in numbers as required, to the shear delivery table.

The finishing end of the 12-inch mill is similar in its equipment to that provided in the larger mill. A roller straightener, gag presses, cold saws, etc., considerable storage or inspection space, shipping trackage, and two 10-ton cranes are included in the facilities.

Roll Shop.

A roll shop has been provided adjacent to the 12-mill building with three motor-driven roll lathes of 34, 26 and 18-inch swing respectively, all with double beds, having a capacity for turning six rolls at once. Here also are installed a number of machine tools for making quick mill repairs. The shop is 35 x 100 feet, well-lighted with side wall sash and skylights. It is served by a 5-ton crane, a small transfer track being used for delivering rolls to both mill buildings. The entire complement of rolls used in the mills have been designed and turned here. All steel rolls, together with mill pinions have been made in the Scullin foundry, and an unusual record of high tonnage and no roll breakage speaks for the success of the Company's premier efforts in this line of work.

Water System.

The high pressure water system, from which are operated the blooming mill roll balance, up-cut shears, ingot turner, etc., consists of two 300 gallon per minute, Aldrich triplex pumps which are direct driven, each by a 150 hp General Electric motor. The accumulator which is of fixed cylinder type was manufactured by the same Pump Company. It is counter-weighted with concrete blocks to maintain the 550 pound per square inch pressure.

The water for the low pressure system, which feeds the mill rolls and furnace skid pipes, in addition to other equipment which requires cooling, is handled by two 2,000 gpm Dayton-Dowd pumps, each direct connected to a 75 hp General Electric motor; one pumping from a cold well and distributing through an 8-inch line the cooling water to the skids and mills; the other, from the well to which the hot water is drained, through a 10-inch line, to the spray header mounted in a valley formed by the roofs of two of the mill buildings. Here branches with some 50 impact spray nozzles effect the cooling of the water, which drains bac kover the 150 feet false roof to the cold well.

Sub-Station.

Power for all plant operations is purchased from the Union Electric Light & Power Co., untransformed at 13,200 volts. A brick and concrete sub-station, 50 x 54 feet, houses the six Westinghouse, 1000 kva transformers and 500 kw rotary converter, distributing 2200 and 220 volts alternating current, and 230 volts direct current to main drive and mill auxiliaries.

The switchboard of 14 panels was furnished by the General Electric Company. All main feeder and transformer oil switches are solenoid operated. Every precaution has been taken for safety and fire prevention, all cell work being of concrete, while the feeder lines and busses are thoroughly protected by concrete insulating walls.

Service Building.

A service building of concrete and brick construction, 50 x 80 feet, houses the store-room, hospital, and mill offices, parts of two floors being used as wash and locker rooms for mill hands. Great care has been taken to insure cleanliness in the building and to provide for the comfort of the men. The showers, lavatories and toilet facilities are of the most improved and sanitary types. Each workman is provided with two lockers for street and working clothes.

A first aid attendant is always on duty to care for minor injuries in the first aid room, while other welfare work throughout the plant has been given careful attention. Guards, hand rails, etc., have been installed and belts substituted by direct motor drive to add to safety of employees and eliminate possible hazard.

The two main buildings are of typical mill type construction but unusually well lighted and ventilated by mechanically operated Fenestra continuous sash in all sidewalls and monitors. Both are approximately 76 x 500 feet. The billet storage yard and furnace charging shelter occupy a 60 x 500 feet space between them.

All machinery was erected and pipe and electrical work installed by the mill organization. The buildings and foundations were constructed by Fruin-Colnon Contracting Company of St. Louis. The engineering and construction work was in charge of Frederic B. Menner, manager of this department of the Scullin Steel Company, and Perin & Marshall Co. of New York, acting as consulting engineers. George H. Raab is superintendent of the mills.

Mill Table Equipment That Reduces Cost

Recent Tendencies to Lower Selling Prices Make Necessary Some Thought Toward Reducing Operating Costs in Every Manner—Flexible Roller Bearings Assure a Decrease in Cost Per Ton.

By J. M. KELLY, Engineer,
Hyatt Roller Bearing Company.

TO be "right up to the minute" in mill construction and design has many advantages as well as the few disadvantages that have been pointed out in these columns from time to time. The modern construction naturally costs more than the older types of mills but more tonnage at less cost per ton can be produced on the modern mill taking into consideration that sufficient tonnage of but a few standard sizes, lengths, etc. can be booked thus keeping the mill operating with few of the costly delays that are inevitable when small tonnages necessitate several roll changes.

The modern equipment contains all that is essential to keep down the cost per ton of the finished product. In a pronounced majority of the recent modern mill table installations, engineers have given special attention to the question of table roller bearings. It has always been the desire to design tables that will function properly with little upkeep to the vital parts. Bearings and gears on table rollers and line shafts cause considerable trouble and frequent delays and replacements of an inferior piece of the equipment add an appreciable item to the cost per ton of the product. In the modern mill installations these items of upkeep and maintenance, although not entirely eliminated, have been reduced to a minimum by the use of flexible roller bearings.

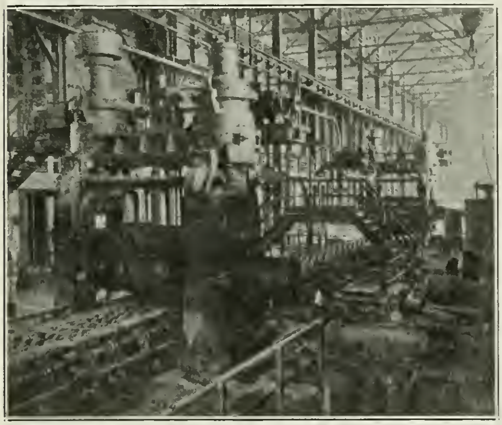

Fig. 1—84-inch Tandem 3-High Plate Mill, Brier Hill Steel Company, Youngstown, Ohio. All tables equipped with Hyatt Roller Bearings.

Plate mill tilting tables, especially those tables where the plate being rolled extends out beyond the bearings, must have real bearings capable to withstand the severe temperatures and the knocks and abuse that are incident to such equipment. Several plate mills have been built within the past four years with flexible roller bearings on the tilting tables. Other plants have found it necessary to rebuild tables and in such instances have incorporated the flexible roller bearing. In adopting such equipment that seemingly is radical from previous practice, progress in mill table design has been satisfied. But this satisfaction of progress is insufficient. A substantial return on the investment is required. This return has been realized by cutting out delays and upkeep, thus reducing cost per ton of steel. Added advantages assist toward the reduction in cost.

It is natural to assume a reduction in power consumption when an anti-friction bearing of the flexible roller type is incorporated. The first comparative test, made in 1916, between flexible roller bearing equipped tables and plain bearing equipped tables was conducted at one of the large Youngstown plants. A small section of table on a billet mill was found to consume 15 hp with the plain type bearings. The flexible roller bearing was substituted and, after two and one-half years of service, a power reading was taken. The flexible roller bearing equipped table required only 52 per cent of the power that had been required to drive the same number of plain bearing equipped table rollers. Had the line shaft bearings been equipped in the same manner only 40 per cent of the plain bearing power would have been required, thus effecting a saving of 60 per cent in power consumption.

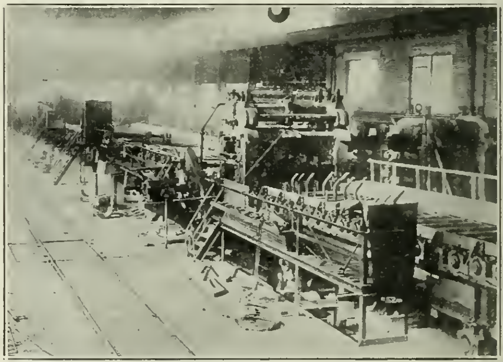

Fig. 2—35-inch—3-High Blooming Mill, John A. Roebling' Sons Company, Trenton, N. J. All tables equipped with Hyatt Roller Bearings.

During the entire two and one-half years of service there had been no replacements of flexible roller bearings. Gears, journals and bearings proved to be in perfect condition. In fact, the original grinding marks could be distinguished on the roller bearings, no wear being perceptible.

No attention had been required other than an occasional lubrication. The roller bearing journal boxes had been properly designed to retain lubricant without excessive leakage that generally accompanies the common type of bearing. Cleanliness and no danger from fires was in evidence.

Plants which have had experience with both types of bearing installations on mill table equipment have given various figures as to what has been accomplished in the way of savings. One plant where an 84-inch plate mill operates reports a decrease of 60 per cent in power consumption and 70 per cent in upkeep and maintenance, since the flexible roller bearing has been in use. Another plate mill that operated with common bearings on the tilting tables found it necessary to spend $500 per month for bearing upkeep and maintenance on gears, the latter depending on proper bearing alignment.

When flexible roller bearings were installed on new tilting tables for this mill, total upkeep was reduced 75 per cent, during the year that the new tables have been operating.

A modern combination structural and bar mill was designed for a plant in the South. The ring-oiled bearings, originally designed for the tables, were higher by $6.00 per bearing than the flexible roller bearings that were incorporated into the tables when finally built. The reduction in first cost of this installation made possible a smaller overhead. During the past two years of operation, upkeep has been negligible. Gears are maintained in their proper positions. There is no chance for the gears on table rollers to sag and get out of mesh with the line shaft gears. The flexible roller bearings are operating day in and day out without causing the wear that would allow gears to get out of alignment, as would have been the case with ordinary bearings.

The recent tendencies to lower selling prices make necessary some thought toward reducing operating costs in every conceivable manner. There is no better method to assist in attaining decreased cost per ton than by investing in table bearings that decrease maintenance, decrease power consumption, and operate efficiently under the adverse conditions that are incident to steel mill practice.

On mill table equipment, the flexible roller bearing assures a decrease in cost per ton of the finished product. Engineers and operating men are insistent on such bearings since actual operating experience on tables of bar, billet, plate, band, strip and blooming mills has developed:

1. Power consumption reduced 50 per cent minimum.
2. Less wear on bearings, journals, gears.
3. Minimum replacements.
4. Less lubricant consumption.
5. Less attention.
6. Cleanliness and no danger from fires.
7. Simplicity of design.
8. Fool proof installation.

Electric Furnaces for Making Steel

Classification of Electric Steel Making Furnaces—General Features and Advantages of the Arc Furnace and the Resistance Furnace—Operating Features of Electric Furnaces.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART II.

THIS furnace was invented by Ivar Rennerfelt of Stockholm about the year 1912 and was first employed on a small scale for melting steel in small foundries at Halstahammar and other places in Sweden. The furnace, like Stassano's, is heated by an independent arc, but the electrical supply is so arranged that the arc blows downwards and thus heats the contents of the furnace more directly.

The Rennerfelt furnace has three electrodes A. B, and C, Fig. 7, which are supplied with two-phase current; the vertical electrode, C, serving as a common return for the two phases. An electric arc is formed between the tips of the three electrodes, and the magnetic force that is exerted by the current flowing in the vertical electrode, forces the electric arc downward. The action of the arc is shown more clearly by stopping the current supply of one electrode, so that there remain only two electrodes, B and C, carrying single-phase current. When this has been done it will be found that the arc blows out in a direction bisecting the angle between the electrodes.

This action of the arc can be understood from Fig. 8, in which A-B and C-D are the two electrodes in which the current is flowing in the direction A-B C-D, as shown by the arrows. As a conductor carrying a current is surounded by circular lines of force, it follows that at B-C, owing to the crowding of these lines inside the angle, there will be a resultant magnetic field perpendicular to the plane of the figure. In consequence of this the electric arc B-C, being a movable conductor, will be made to move in the direction E-F.

If the electric current had been supplied only to electrodes A and C in Fig. 8, the arc would have been directed downwards and to the right, and when current is supplied to the three electrodes the arc moves straight down, this being the resultant direction of the flames that would be produced by the two single-phase currents.

An early form of the furnace Fig. 9 had other novel features in addition to the arrangement of the electrodes. The furnace was constructed in a horizontal cylindrical drum, mounted on trunnions through which passed the lateral electrodes, and the lining of magnesite brick was circular, as shown in the figure, so that the roof, walls and hearth were all parts of a circular lining. A hearth-lining of magnesite was laid over the brick-work of the lower half of the furnace. Only one door was provided for a

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furnace of moderate size, and this served for charging, for repairs to the furnace and for pouring the melted steel. A circular lining within a steel shell would seem to be a very strong form of construction and permits the use of magnesite brick for the roof instead of the more common silicia brick. A lining of asbestos is placed between the shell and the brick-work, in order to retain the heat and to allow the bricks to expand. The electrodes enter through air-tight holders and, as there is only one door, it should be easy to prevent the entrance of air into the furnace, and thus to save electrode-consumption, oxidation of the steel and loss of heat.

The circular construction of the furnace does not permit of easy repairs or replacement of the roof of the furnace, and in later forms this special feature has been given up and the furnace is made circular in plan and has an arched roof that can easily be replaced. This change may have been brought about in part also on account of the extreme difficulty, during the war, of obtaining magnesite bricks, and the consequent necessity of using acid linings.

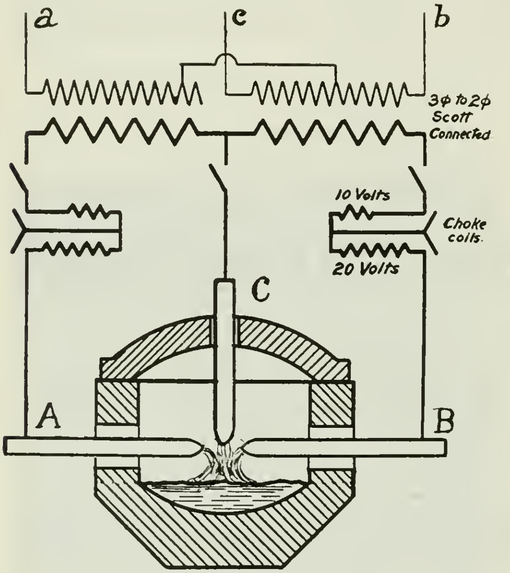

Fig. 7—Rennerfelt Furnace.

Another improvement is the arrangement for altering the inclination of the lateral electrodes. In the earlier furnaces these were horizontal or slightly inclined downwards but were incapable of vertical adjustment. The present arrangement allows of the electrodes being raised to accommodate a full charge of scrap, and as the charge melts down the electrodes can be lowered to keep the arc close to the metal. By this means the arc is kept within 3 inches of the bath during the whole operation, and the flame of the arc spreads out into a circular patch on the slag of 8 or 10 inches diameter, while at times the flame appears to cover the whole bath.

When the charge is completely melted the electrodes can be lowered until the arc passes from each electrode to the slag and metal, so that the furnace has the advantage of direct-arc heating during the refining period.

Referring again to Fig. 7, it will be seen that the wires, A, B and C, carrying high voltage three-phase current, are led to two transformers having the Scott connection, and from these, low-voltage two-phase current is supplied to the furnace by means of three cables. With this arrangement, the middle electrode, which serves as the common return for the other two, carries 52 times the current in each of the lateral electrodes, or 40 per cent more than each lateral electrode is therefore made proportionately larger.

The Rennerfelt furnace, like the Stassano furnace, having an independent arc, is able to use current at a higher voltage than is usually found desirable in direct-heating arc furnaces, and this, in spite of the fact that only one arc is produced, while in the Heroult furnace there are two arcs in series. Any increase in voltage results in economy in transformers, bus bars and cables as well as in electrodes and electrode holders; it also reduces the electrical and thermal losses in the electrode and thus raises the electrode-efficiency. As a rule the voltage of each phase is about 100 (or 140 volts between the two lateral electrodes) but 110 or 120 volt supplies have recently been employed and this can be lowered to about 60 volts per phase for use during the refining period, when the arc is playing between electrode and charge and when a smaller rate of heating is desirable.

When the charge has melted and the furnace is fully heated, the 100-volt two-phase arc is very steady and affords a satisfactory load for the power-supply, but when the furnace has been freshly charged with cold scrap, there is some difficulty in keeping a steady arc with the full voltage. The earlier furnaces were provided with rheostats in series with the lateral electrodes for the purpose of steadying the arc at this period, and this caused a serious loss of power, but at present reactance coils, marked "choke coils" in the figure, are used for the same purpose and are cut out by switches as soon as they can be dispensed with. A recent tendency, in this as in some other furnaces, has been to provide a larger amount of power for a furnace of a given capacity; thus from 200 kw to 300 kw per ton of furnace capacity is now provided, instead of from 100 too 200 kw as in the past, and this change, besides lowering the melting-cost, increases the steadiness of the electrical load. Thus, in a three-ton furnace, which is drawing 600 kw the load will decrease steadily, owing to the burning of the electrodes, until after 5 minutes, it will have dropped to 550 kw if no regulation of the electrodes has been made meanwhile.

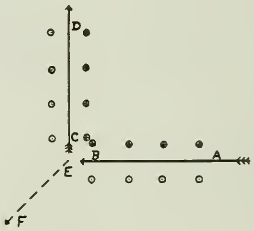

Fig. 8—Action of Arc in Rennerfelt Furnace.

The electrodes are of Acheson graphite and are provided with threaded joints for connecting additional lengths, so that there is no loss by wasted stub-ends. Graphite electrodes, on account of their smaller cross-section, are particularly desirable in furnaces of this type, especially when it is desired to adjust the electrodes to different angles. The vertical electrode might be made of carbon, but even here the graphite electrode has the advantage of needing a smaller opening in the arch. The regulation of the electrodes is usually by hand, which is practicable with this furnace, as a high-voltage arc, when working steadily, needs less frequent regulation than a short low-voltage arc. The middle electrode is always regulated by hand, being moved downwards from time to time, so that its end is between the ends of the other electrodes, but in some recent furnaces automatic regulation has been applied to the lateral electrodes.

The width of the Rennerfelt furnace is limited by the length of the lateral electrodes, which must reach to the middle electrode for striking the arc. The furnace, is 42 inches in diameter, inside the lining and 6 feet in diameter inside the shell, and has a capacity of 1500 pounds. This requires a length of unsupported electrode of about 30 inches. For furnaces of more than about 7 feet internal diameter and 6 tons capacity, the circular form would probably be given up, the furnace being built oval in plan and being provided with two or more sets of electrodes. The construction of a large furnace, with multiple electrodes, will be seen by reference to Fig. 11, which represents a 40-ton furnace. The design shown, however, is of the older cylindrical type, and this would probably be modified in view of later experience so as to permit of ready replacement of the roof.

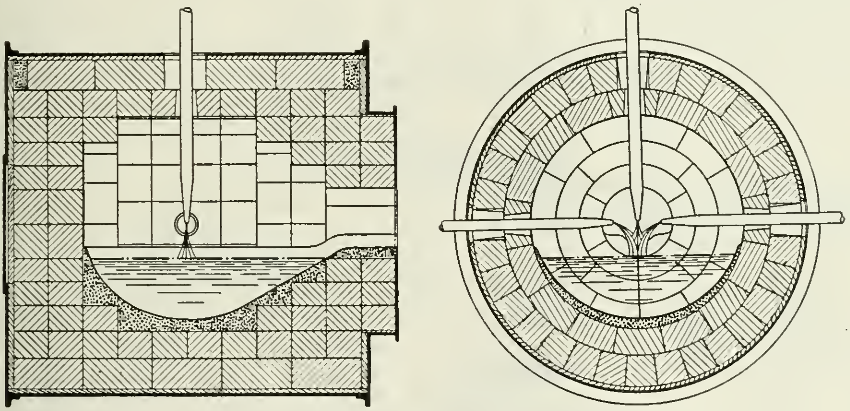

Fig. 9—Early Form of Rennerfelt Furnace.

Up to the present Rennerfelt furnaces have been of small and moderate sizes, the largest having a capacity of 3 or 4 gross tons and a power of 800 or 900 kva. They have been used in general for melting steel scrap, and for this purpose they seem to compare favorably with furnaces of the same size of the direct-heating arc types, while they have additional advantages as regards steadiness of load during the melting period. A steel foundry making small steel castings with an acid-lined furnace, which is only operated during the daytime, gives the following results as typical of a days' run:

Heat No.	Charge pounds	Time hours	Kw hours
79	1900	4.0	800
80	1800	3.7	520
81	1825	3.4	520
82	1800	3.0	490
—	—	—	—
Total	7325	14.1	2330
Average	1831	3.5	637 Per net ton.

The electrode consumption was from 8 to 11 lbs. per ton.

Basic lined furnaces of 300 kw for a ton capacity, and taking off one slag, have been operated continuously with 670 kw-hours per ton, finishing the heat in 2½ hours. The electrode consumption is said to be under 6 pounds per ton of steel, in continuous operation, and the refractory costs are also moderate; silica roofs lasting in several instances for at least 250 heats, and silica side-walls over 300 heats.

The American makers, Messrs. Hamilton and Hansell of New York, give the following rating of their furnaces:

Type	Capacity (Steel)	Transformer rating (40° C. normal rise)
O. special	100-200 pounds	40- 60 Kva.
O.	300-500 "	80- 100 "
1-A.	1000 "	150- 200 "
11-B.	1 gross ton.	350- 400 "
IV.	3 to 4 gross tons	800-1000 "
V-A.	5 to 6 gross tons	1200 "

The makers give the following estimate of the cost of 1 ton (2,000 pounds) of molten steel. The figures refer to the continuous operation of a 1-ton furnace:

Labor, 2 shifts of two men each	$ 2.12
Scrap, 1900 pounds at $30.00 a ton	28.50
Pig-iron, 100 pounds	1.75
Ferro-manganese, 15 pounds	1.72
Ferro-silicon, 8 pounds	.64
Melting loss, 2 per cent	.60
Iron Ore	.10
Aluminum, coke and fluors par	.25
Power, 700 kw hours at 1 cent	7.00
Electrodes, 8 pounds at 22 cents per pound	1.76
Refractories	.95

Maintenance and repairs	1.70
Water, tools and incidentals	.15
Interest and depreciation	2.00
Total cost of 1 ton of steel in ladle	——$49.24

If we take away the cost of the pig and scrap, which vary continually, but leave in the melting loss and all other items, we obtain the figure of $19.00 as the conversion cost of one ton of molten steel.

This estimate was supplied during 1918 and should represent war conditions, but the charge for labor will probably be higher in most places at the present time. If we assume that ten heats of one ton each are poured per day, the rate of wages on the above estimate work out to 44 cents an hour, and this does not allow for interruptions. Power can be obtained in many places at less than 1 cent per kw-hour, but this figure will provide for irregular use of the furnace.

In addition to their use for steel castings, Rennerfelt furnaces have been employed for making tool-steel and special alloy steels, for melting ferro-manganese and for iron foundry work. They have also found extensive use in melting copper alloys, bronze, cupro-nickel, etc., for which they are well suited, as the independent arc will cause less loss by volatilization than the direct-heating arc of most electric furnaces.

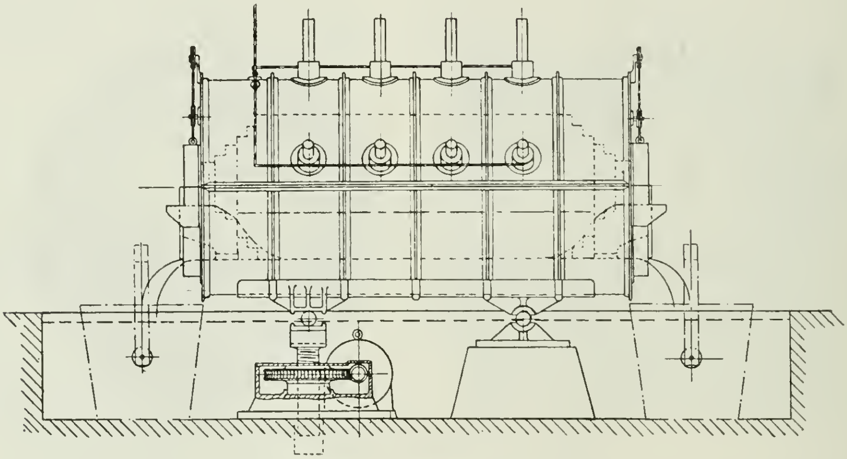

Fig. 11—Rennerfelt Furnace with Multiple Arc.

There are now more than 150 Rennerfelt furnaces in operation and under construction throughout the world for steel-melting and other uses. They vary in capacity from a few hundred pounds up to three or four tons, a large number being of about one ton capacity. Furnaces may in time, be built of large capacity, on the multiple arc system, for refining molten steel, but for this purpose the Rennerfelt furnace does not seem to offer any great advantage as compared with other types of furnace.

The following figures are given by the makers, as the power-consumption for melting various materials in small furnaces of the Rennerfelt type 5, in kw-hours per metric ton:

Power Consumption for Melting Per Metric Ton.

Red brass	168	kw.-hrs.
Pure copper	197	"
White iron	290	"
Gray iron	325	"
Ferro-manganese, 80 per cent	441	"
Steel scrap, not ready to pour	455	"
Steel scrap, melting and "killing" on an acid bottom, about	600	"
Steel scrap, melting and refining on a basic bottom, about	700	"
Ferro-manganese, 80 per cent, melting, holding, tapping and charging	741	"
Making 67 per cent ferro-tungsten on small scale	5730	"

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2. "The use of liquid ferro-manganese in the steel furnace." Axel Sahlin, Iron and Steel Inst., 1914 II. page 213.
3. "Electrothermic smelting of iron ores in Sweden." Alfred Stansfield, Dept. of Mines, Ottawa, 1915, page 51.
4. A discussion by G. Muntz and Ivar Rennerfelt of the use of electric furnaces in the steel-foundry.
   Met. and Chem. Eng., June, 1914, vol. XII, page 379.
   Met. and Chem. Eng., Sept., 1914, vol. XII, page 581.
   Met and Chem. Eng., Feb., 1915, vol. XIII, page 108.
5. "The Rennerfelt Arc Furnace," C. H. Vom Baur. Amer. Electrochem. Soc., 1916, vol. XXIX, page 497.
   Met. and Chem. Eng., 1916, vol. XIV, page 479.
6. Electric Furnace for independent and direct-heating arcs, patent, C. W. H. Eckermann and I. Rennerfelt.
   Met. and Chem. Eng., January, 1917, vol. XVI, page 53.
7. "Rennerfelt electric furnace operation," C. H. Vom Baur. Amer. Electrochem. Soc. 1917, vol. XXXI, page 87. Met. and Chem. Eng., May, 1917, page 580.
8. "The Rennerfelt Electric Arc Furnace," 1919. Messrs. Hamilton & Hansell, Inc., 17 Battery Place, New York.

Editor's Note—The June issue of The Blast Furnace and Steel Plant will contain several special features. In addition to the report of the American Iron and Steel Institute, a special Power Department will be included. The feature of this will be a complete write-up of the most modern steam power plant in the steel industry.

Heating Furnaces and Annealing Furnaces

Requirements Which Sheet and Pair Furnaces Must Meet—Comparison of Different Types of Sheet Furnaces.

By W. TRINKS.

PART XXVIII.

IN continuing the critical discussion and comparison of different types of furnaces, let us turn our attention to the furnaces which are used in the manufacture of steel sheets and of tin plates. It will be remembered that steel sheets and tin plates are rolled from sheet (or tin plate) bars of about 8-inch width, and of length equal to the width of the sheets which are to be rolled. The thickness of the bars varies from ¼-inch to 1½-inch, depending upon the length and thickness of the sheets which are to be produced from the bars. The sheet bars as well as the sheets themselves are exposed to the air for a long time during the rolling process and would scale excessively if the temperature were high. In consequence, sheets are rolled just above the critical temperature, that is to say at about 1400 degrees F., while sheet bars are rolled 100 to 150 degrees F. hotter. The low rolling temperature results in tremendously high forces between sheets and rolls, reaching 50,000 pounds per inch of width of sheet. At that high pressure any scale which might be formed is rolled into the sheets and mars the rolls. Furthermore, the sheets, which are rolled in packs, will stick together, if pure metallic red hot surfaces come together.

The furnaces in which sheet bars and sheets are heated must, in accordance with these peculiarities of manufacture, meet the following requirements:

1) Furnaces must suit the mill layout and the method of rolling.
2) The sheets must not oxydize in an irregular manner. No loose scale must be formed.
3) The sheets must be free from ashes or soot.
4) The sheets at different sides of the pack must have the same temperature.
5) A thin, uniform, firmly adhering layer of oxyde must be formed of such a nature that it stretches with the sheets in the rolls without cracking.

The old Welshmen who brought the knowledge of the art of rolling sheets to the United States appear to have been well acquainted with these requirements. In any event, the equipment which they had made possible the rolling of very good sheets. Improvements have been made from time to time; however, some of these so-called improvements resulted in a very poor grade of sheets, and were later on abandoned.

The different requirements will now be taken up in order:

1. Sheet mills are strung out in a long line, many mills being driven by one motor or one engine. At each mill the sheet bars are heated in one furnace, are taken across the working floor to the mill and are rolled, first singly, and then in pairs. The furnace in which they are heated is known either as a sheet bar furnace, or more commonly as a pair furnace. When the pairs have been rolled out to a certain length, they are doubled, and reheated in the sheet furnace, which must likewise be located handy to the mill. The customary arrangement of one unit is shown in Fig. 210. The sheets are then rolled to final length. If thin (light) sheets are to be rolled, the pack is again doubled, reheated and then rerolled. After the final rolling, the sheets which have been rolled together, are opened or stripped apart.

From this process it is quite evident that the operating doors of both furnaces must face the working floor side by side, or else be just around the corner.

2. No loose oxide or scale must be formed, because it would spoil both the appearance of the sheets and the surface of the rolls. This requirement means that the furnace atmosphere must be neutral or reducing, no excess of air being permissible in the gases of combustion. Loose scale absorbs and holds products of combustion. This sort of scale breaks in the rolling process, allowing streaks of pure metal to come together and to weld together under the pressure of the rolls. It is thus productive of stickers and wasters.

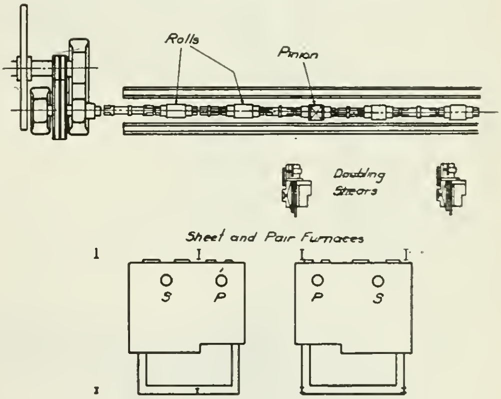

Fig. 210.

3. The requirement of keeping ashes or soot away from the sheets needs no comment, because any foreign material spoils the appearance of the sheets. Ashes injure the rolls also.

4. The requirement that the sheets must have the same temperature at both sides of the pack is easily understood. If one side is colder than the other, the pack will either curl or roll loose, both of which are undesirable. Besides, rolling below the critical temperature causes a cold flow and hardens the material.

5. The requirement of the formation of a very thin layer of magnetic oxide has quite frequently been overlooked, but is nevertheless very essential. The sheets must not have a pure metallic surface, because they will stick together due to the tremendous pressure between the rolls. On the other hand the oxide skin must be so thin and so even that it will stretch

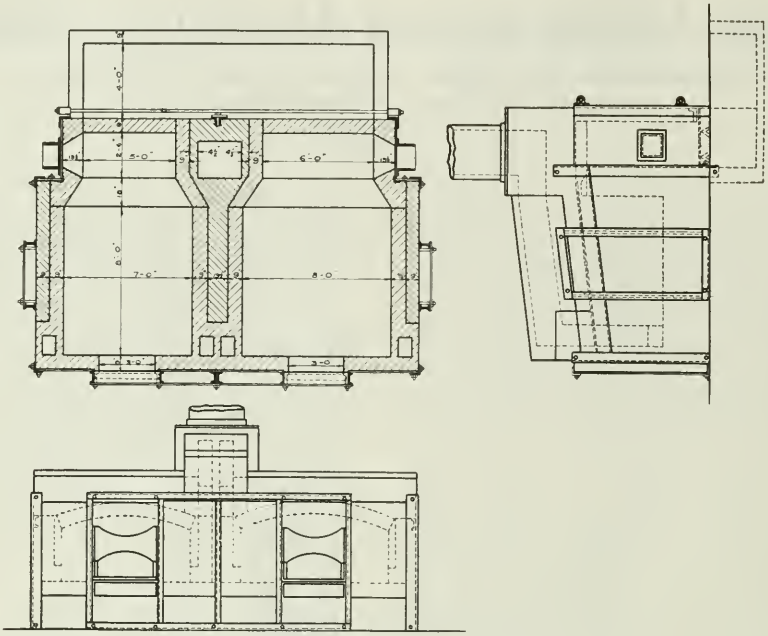

Fig. 212

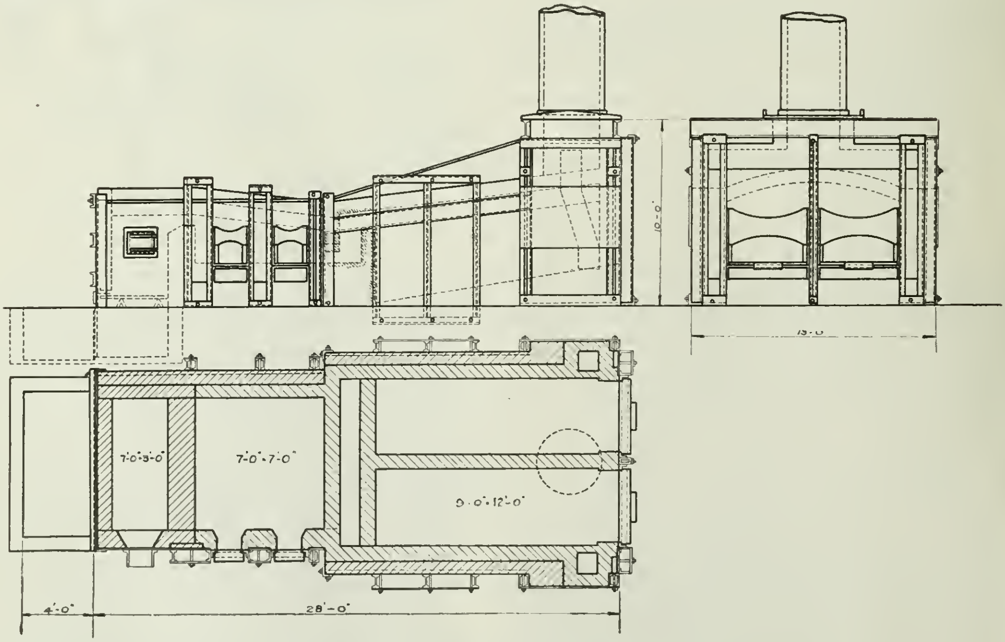

Fig. 211.

with the sheets without cracking. The oxide coating must stick firmly to the sheets. From all that I have been able to find out, the right kind of oxide skin cannot be formed unless there is water vapor present in the furnace gases.

If that assumption is correct, sheets cannot be heated with a coke fire, unless steam is blown under the fire, or natural gas is burnt with the coke. Whenever bituminous coal is burnt properly, water vapor is present in the flue gases, with little or no free oxygen.

With all of these requirements in mind, the comparison of the different types of furnaces can be made without difficulty.

Fig. 211 shows a combination sheet and pair furnace of a type which was, at one time, widely used, and of which many are still in use. The furnace is hand-fired, the flame spills over a bridge-wall, hugs the roof of the pair furnace on account of its lightness, drops down to opening just above the hearth, rises over a second bridge-wall, hugs the roof of the sheet furnace, and passes out through ports near the doors, at the hearth level. The advantage of this furnace type lies in the utilization of fuel. The pairs (sheet bars) needing a higher temperature than the sheets, are heated by the hottest flame. The disadvantage is, that it is almost impossible to regulate the temperature of the sheets and of the sheet bars independent of each other, and that there exists the danger of air infiltration through the pair furnace, unless pressure is maintained at all times in that furnace.

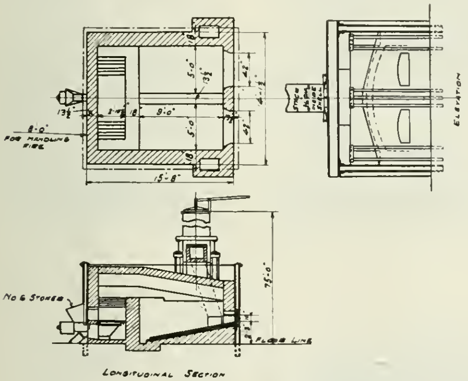

Fig. 213

Many heaters prefer to have the furnaces side by side as shown in Fig. 212. Both furnaces are fired independently, condition of furnace atmosphere can be regulated independently and fires can be cleaned at different times. There is only one stack with one damper for both furnaces, but bricks can be put into the ports of either furnace, and the relative draft conditions can thereby be regulated.

Fig. 126, which was originally published in part XVIII, shows the coal fired end of another side-by-side sheet and pair furnace.

For many years, hand-firing with good lump gas coal was considered to be the only correct method of heat production for sheet furnaces. This method has its advantages and its disadvantages. The flow of air and the rate of combustion can be regulated by the depth of the fuel bed and of the ash bed, in conjunction with adjustment of the stack damper. The heater knows that the fire needs attention every 35 to 45 minutes; there is no chance of the fire changing suddenly in its character. By making the grate surface large, 20 to 25 per cent of the hearth area, the designer can enable the heater to work with a slow fire. In that case the fuel bed acts like a gas producer, and yet uncombined oxygen will pass through the voids, between the lumps of coal. Stratified parallel streams of excess combustible and of unconsumed air, rise from the fire with the low velocity of two feet per second and do not mix to any extent until the flame rolls over the bridge wall.

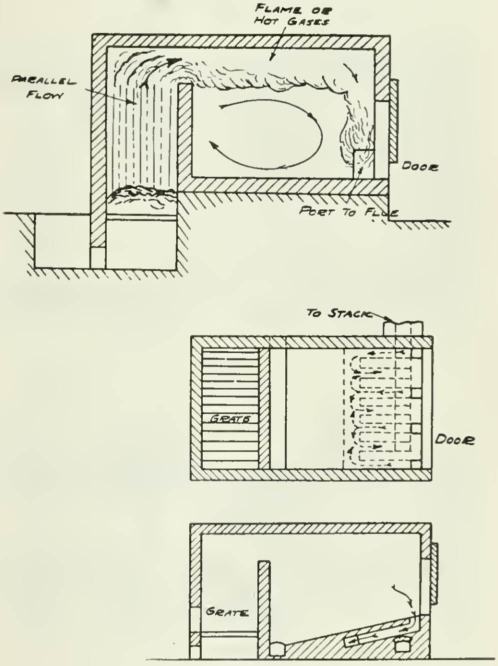

Fig. 215

The flame is always hotter, and in consequence, lighter than the rest of the gases in the heating chamber. If the flame is the least bit smoky, it can be seen rolling along the roof, acting like an inverted river and burning as it rolls along. The temperature of the flame is practically constant so that front and rear of furnace have the same temperature. The flame moves down the front wall, and occasionally licks out through the door which, by necessity, must be open most of the time, at least in the sheet furnace. A hood over the door carries off the little tongues of smoke and flame. There is still a large amount of

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The question of formation of scale has been investigated by Prof. Kowalke of the University of Wisconsin. In a paper before Wisconsin Gas Association, March, 1919, he gives the equation for formation of magnetic oxide by water vapor:

$$3Fe + 4H_2O = Fe_3O_4 + 4H_2.$$

combustible matter in the flue gases when they leave the furnace; flame and black smoke frequently appear at the top of the stack, particularly at a time immediately after firing.

While many mill superintendents still prefer hand-firing, others prefer underfeed stokers, particularly the old "American Underfeed" which is now being built by the Combustion Engineering Corporation, and is being sold by the G. H. Hagan Company of Pittsburgh. Successful hand-firing requires good lump coal; slack will not do, while the underfeed stoker can burn slack quite successfully. Both users and builders of that stoker state that a ton of sheets can be produced with 100 to 150 pounds of coal less than if hand-firing is used. However, the stoker requires just as careful operation as hand-firing does. Some heaters say that it requires even more careful attention than hand-firing does. If it is properly adjusted and if the ash pit doors are kept closed, blast from the tuyeres escapes into the ash pit and crosses the grate bars again further from the center. While the type H Combustion Engineering Corporation stoker is at present the best furnace stoker on the market, it is far from being perfect. It is equipped with hanging clean-out doors which admit excess air, if there is the slightest suction in the combustion space. In some of the plants, the heaters keep these doors mudded up with clay. Furthermore, the stoker is not self-cleaning and requires as much labor as hand-firing does with respect to cleaning. The Jones stoker, which is now being built by the Underfeed Stoker Company of America, has the great disadvantage that there are dead plates at both sides of the tuyere box. Combustion is localized, high temperatures are localized and clinkers are formed. However, I understand that these defects are now being remedied.

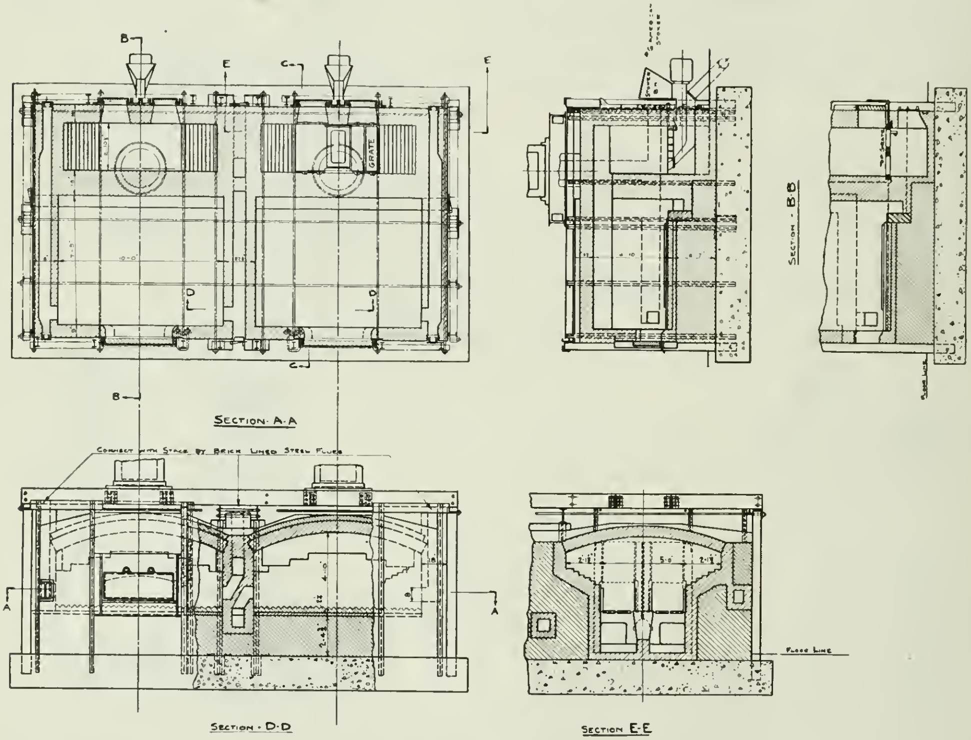

Fig. 214

Two types of furnaces are shown in Figs. 213* and 214. Fig. 213 is a single furnace with a dividing wall, while Fig. 214 shows a double furnace. The divided furnace is liked by many heaters because it furnishes more wall space against which to lean sheets. When sheets are first put back into the furnace they are stood against the wall ("worked against the wall"). This feature, by the way, determines the minimum height of the furnace. Then as the heat progresses the heater flops them down on the hearth, thereby obtaining exposure to the radiant flame on both sides. With heavy packs of sheets, this handling and flopping around of the material is a hard, heavy and hot job, which requires relay teams, each man working only a short time in front of the furnace. The day will come when continuous sheet mills and continuous sheet furnaces will be built, in spite of the tremendous difficulties which must be overcome, and then all of this hard and unpleasant work will be done away with.

The inclined floor in Fig. 213 is found in many other sheet furnaces. It makes possible the use of a lower bridge wall and increases flue gas circulation in the furnace, which fact will be more fully explained below. The inclined hearth is also supposed to afford easier manipulation of the sheets.

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*Furnished by the G. H. Hagan Corporation.

Fig. 214 shows several features which are found in good sheet furnaces. It shows the corrugated tile, and clean-out flues. The corrugated tile allows circulation of the hot flue gases under the sheets, see Fig. 215.

Viscous drag and heat of the bridge-wall cause a circulation of the furnace atmosphere as indicated by the arrow. By allowing the gases to circulate through the corrugations of the tiles a semblance of a hot bottom is maintained. The corrugations indeed furnish a substitute for the old Welsh hollow hearth. Many heaters contend today, that a hot bottom is necessary for the successful heating of the sheets, particularly if many small ports are provided near the door as shown in a sketchy manner in Fig. 216.

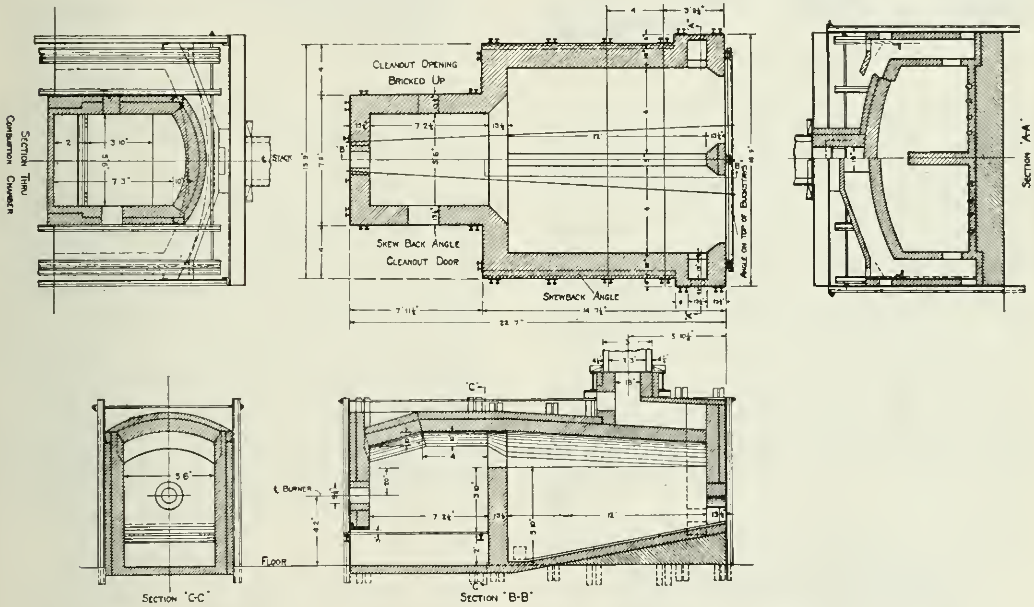
Section Thru Combustion Chamber
Stack
Cleanout Opening Bricked Up
Skew Back Angle Cleanout Door
Skewback Angle
Angle on top of Buckstays
Section 'A-A'
7' 2¼"
12'
7' 11¼"
14' 7¼"
22' 7"
5' 10½"
5' 6"
Burner
Floor
Section 'C-C'
Section 'B-B'

Fig. 217

The underground flues are very desirable if an experienced heater operates the furnace. To make the flue gases heat the hearth from underneath, there must be very little infiltration of cold air around the door. To this end the grate level should be below the door level, and the flue openings must be in the hearth. The stack damper must be so operated that just enough air comes in to allow combustion to reach into the flues under the hearth. This whole adjustment is quite delicate and few heaters can be found to handle such a furnace correctly. If the furnace is improperly handled, the flue gases passing under the hearth actually absorb heat from the hearth and cool it. For that reason the hollow hearth has been given up in most furnaces, in spite of the most excellent service it gives in the hands of skilled operators.

In Fig. 214, there is a groove or pit between the hearth and the bridge-wall. Dirt and scale are blown into it from the hearth by steam or compressed air after every heat, or once a turn. When the pit is filled, it is cleaned out through the cleanout opening provided for that purpose.

Powdered coal has been used for sheet furnaces, but it is not an unmixed blessing. Fig. 217 shows a furnace in which powdered coal is burnt.** The difficulties which had to be overcome in the general use of powdered coal were discussed in part XVII. In the heating of sheets additional difficulties arise. The most important of these is the trouble experienced with the ash. The latter settles on the sheets and is rolled into their surface, spoiling them, and ruining the rolls. In some places the ash is swept off with a common broom immediately after the removal of the sheet from the furnace. That process, however, does not remove ash that settles between the doubled sheets when they stand up against the walls. In some plants, ash sticking to the roof is removed after each heat, to prevent its falling on the sheets and causing uneven heating.

A second trouble arises from non-uniform grinding. Unburnt coarse particles are carried over into the heating chamber and land on the sheets. The remedies are finer grinding and large combustion chambers. Those sheet mills which have had success with powdered coal owe that success partly to large combustion chamber. The combustion chamber of

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Incidentally, Fig. 215 shows that most of the heat is transmitted to the sheets by radiation, and comparatively little by convection, because only a fraction of the products of combustion circles around in the furnace, while a greater part of the gases passes right out to the flue.

**Falcon Steel Company, Niles, Ohio.

Fig. 217 was originally smaller, and was later on increased to its present size.

A third trouble comes from excess air. It will not do to leave the bottom of the combustion chamber open and to let air find its way into the furnace as it pleases. The supply of air must be under control just as much as the supply of coal. The injurious effects of excess air in a furnace heating thin sheets are quite evident. Insufficient mixing of the powdered coal with the air has a similar effect. Powdered coal, as a rule comes in through a single round burner, which is as a matter of fact only a hole or an orifice. It is rather difficult to have a uniform coal-powder and air mixture over the whole furnace width, as that mixture passes over the bridge-wall. This problem, likewise, is brought nearer a solution by a long combustion chamber. Uniform delivery of powdered coal is likewise of greatest importance. In some systems of coal distribution, slugs or gulps of coal arrive at times and seriously disturb the mixture. In one sheet mill using powdered coal and spoiling a lot of sheets, I sifted the coal through standard sieves and found a surprisingly large amount of very coarse and heavy particles in the powder.

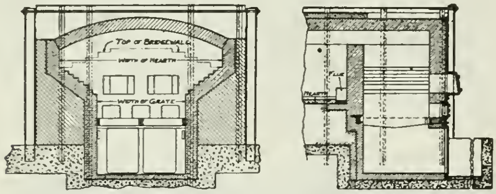

Fig. 216

It can be most emphatically stated that it will never do to use cheap and imperfect grinding equipment and to stick a pipe carrying a coarse powder through the back of a combustion chamber designed for hand-firing. The results will and must be disastrous.

With almost any method of firing, or fuel, it is possible, only too possible, to produce a hot combustion chamber by completing combustion in that chamber. In that case the roof over the combustion chamber is very hot, while the roof nearer to the working door is comparatively cold. Equal and uniform temperature in the heating chamber can, in this case, be procured by carrying a false roof or perforated arch some distance into the heating chamber, see Fig. 218. However, this arrangement is a make-shift and is unnecessary, if a long lazy flame is used. The free end of the perforated arch has a tendency to collapse. With producer gas or with natural gas, the long lazy flame can be obtained by the use of a double bridge-wall through which air is admitted by means of an adjustable door, see Fig. 219. Again, this is an expedient which should not be necessary, because large enough gas ports and air ports can readily be provided in the combustion chamber to produce parallel stream line flow so that the combustion is nowhere near complete when the mixture rolls over the bridge-wall.

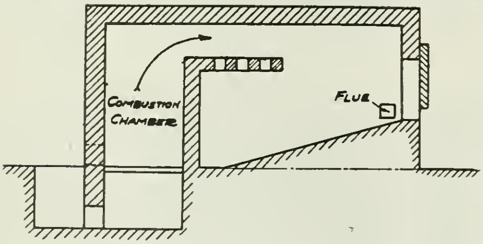

Fig. 218

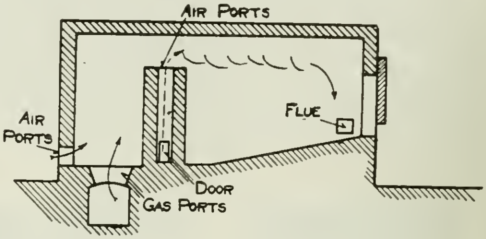

Fig. 219

From the foregoing explanations it is quite evident that, with the exceptions of a few detail improvements, the general method of heating sheets is about the same as it was when the Welsh sheet experts brought the art across the Atlantic. We are still quite far from continuous, automatic heating, free from hard labor and we still depend upon the skill and the eye of the heater as much as ever before. There has been some progress made in the automatic heating of sheet bars. The discussion of the types developed for that work will be left to another article.

In judging the present installment, it should be remembered that it is a discussion of furnace types, and not an investigation of the best methods of producing excellent sheets with a given type of furnace. Such an investigation should be most interesting, but lies outside of the scope of this series of essays.

HIGH HEAT-CONDUCTING REFRACTORY MATERIAL.

A refractory material has been produced at the Perth Amboy, N. J. plant of the Carborundum Company which has a high heat conductivity. It appears that in a sheet metal porcelain enamelling furnace in the plant of the Gribben and Sexton Company, Chicago, it took but six sours to bring the muffle interior up to 1,800 degrees F. A result is that the furnace is now shut down over week-ends because of the relatively small amount of time necessary to bring it up again to temperature. Claims are made of savings in fuel consumption and in increased furnace production, as compared with the fire clay muffle, but exact figures are not available yet. The material has been given the name Carborfax. It is understood the material is also in use for the roof of open hearth furnaces, but here, of course, for its durable refractory property and probably not for heat-conducting capacity.

The Donetzbecken Region of the Bolshevic Government

By DIRECTOR M. ULLRICH.

NOTE—*We are recommending this article to the special attention of our readers. The author was employed in an iron and steel industry of the Donetz region and his work from September,* 1918, *to October,* 1920, *with the Soviet government of the Ukraine as assistant to the director consisted in furnishing technical material to the Donetz region. In this capacity he has had wonderful opportunity to become thoroughly acquainted with the conditions described by him.*

SINCE the ending of the Russian revolution and since the beginning of the Bolshevic expansion endeavors the red armies have fought furiously for the possession of the Ukraine and more particularly for its eastern sections which surround the Dontezbecken region. The fury of the struggle is easily explained from the high value of possession of these sections for the Soviet government. Kijew-berditschew between Ukraine and the Black Sea on the south and the line Charkow-Jekterinoslaw-Kriwoi-Rog on the East with its fertile black soil and its very moderate climate is an economically fertile district the production of which is increased by the quick wit of its occupants in Southern Russia. The possession of this economic center, particularly its east is so exceedingly valuable for the Bolshevists because Donetzbecken region is for Soviet-Russia what the Ruhr district is for Germany. It shows in a geological formation particular deposits of bituminous coal and in addition, strata of zinc ore and of veins containing lead, silver and mercury, as well as the valuable deposits of salt. Very favorable for that section is the immediate neighborhood of coal and ore. Industry in this section is quite young but since it started out from the very beginning with modern plants and modern equipment the production figures gained rapidly before the war. In January, 1901, the Dontezbecken region produced 11.3 million tons of coal, in 1915 it furnished the following:

Product	Per Million Tons
Coal and anthracite....................	28
Steel	2.457
Pig iron	2.72
Semi-finished material	2
Finished material	0.23

The Kriwoi-Rog section produced in the same year 5.36 million tons of ore.

The largest mines are:

Name of Mine	In Million Tons
New Russian Company in Jusowka......	1.12
Union Company in Makejewka..........	1.354
The Russian-Belgium Co. in Jenakijewo.	1.152
Brjansker Company in Jekaterinoslaw...	0.992
South Russian Coal Co. in Gorlowka.....	0.96
Kriwoirog Company in Almasnaja	0.56
Steel Works in Dneprovienne...........	1.12

The efforts of the Soviet government to get possession of the Donetzbecken region are for this reason quite clear. The Ukraine should furnish coal and ore for the factories in the interior of Russia particularly for the reconstruction of the railroads. Without this supply reconstruction is absolutely impossible because the only other coal district which might be considered fairly is the one near Moscow which furnishes insufficient quantities of a low grade fuel. The final occupation of the Donetzbecken region meant for the Soviet government a success which relieved them of quite a load and brought the prospect of obtaining sufficient production for putting the prostrated north region industry back on its feet. The Soviet government thereby accepted a large and fruitful task of organization, in which however, it fell flat although it pretends in its economical policy to emphasize organizing work on a large scale.

When Denikin in the winter of 1919 was vanquished by the shock of the red army and was compelled to finally give up the Dontez region he blasted not less than 247 bridges in this district. For that reason, it was impossible for the Bolshevists to get into communication with the coal mines from Charkow. It was not until April, 1920, that sufficient communication was obtained so that inspection of the mines by representatives of the government could take place. Their reports showed a very sad picture. The condition of the mines was hopeless. All of the mines were without engineering direction because Denikin has taken along most of the engineers from Ukraine. The first task was then to bring together the required engineering personnel for competent direction of the mines. True to Bolshevic style, all the authorities in the Don region and in the Kaukasus were ordered to determine quickly the number of available engineers and to send all of them without delay to Charkow where the distribution was to be made to the different mines of the Donetz region.

The latter was subdivided from the Green table into 16 sections all of which were to be governed from Charkow. The directors of each section had to be strictly loyal communists. They have to report on their activity to the Soviet government in Charkow but have quite extensive plenipotentiary powers and work responsible without paying much attention to the directions of the central administration. Since there exists no mining engineers, which at the same time are communists, the sections are responsibly directed by miners or by pickmen or laborers which of course must be communists. The assistant to such a director must of course be a mining engineer or an experienced foreman. The direction of the individual mines is taken care of by the commission of three men, the operating director, a workman and a representative of the union. True enough, the Soviet government has come to the conclusion and admitted that these commissions do not satisfy the requirements and that only a strong direction can operate the mines in a responsible and paying manner. Under the present conditions, it is utterly impossible for the director to do any useful work because all local authorities and organizations, no matter if they have official business with the mines or not, consider it their duty to mix in with the internal affairs of the individual works. In this manner the tor-

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From Stahl und Eisen.

mented director is often busy all day long answering questions and reproaches of bloody laymen and making reports to them concerning his measures. The operating instructions gives him authority to refuse admission to troublesome intruders but this authority is solely a paper authority. Actually he must not dare refuse if he does not want to gain the reputation of being a counter revolutionist and to expose himself and his family to great danger.

This condition of the industry can be summarized as follows:

1. The supply of food for the workmen is very bad, almost impossible.
2. That the supply of machinery for the mines is wholly insufficient.
3. That the organization of the administration of the mines is far from being satisfactory.

When the Bolshevists in the first half of the beginning of the year 1919 for the first time occupied the Donetz region they closed all the large mines but operated only the smaller mines because of past experiences they would appear in position to produce more coal than the large works with their almost wholly destroyed organization. During the spring of 1920 the same method as was first worked out but was again given up in August. From this time on the smaller mines were shut down so as to turn their operating equipment including all boilers, pumps, engines, etc., to the large mines. As might be expected, this measure soon turned out to be a great mistake because the large mines on account of their tremendous requirement, of mechanical equipment could not be made sufficiently operative in spite of the turning over of equipment from the smaller mines; and could scarcely produce their own fuel requirements, whereas the smaller mines, which up to that time, could at least produce some coal were entirely eliminated. The expected increase in coal production, therefore, did not materialize, and yet Soviet-Russia was yelling for more coal. However, for the government the Donetz region is in fact the land of the "black gold" as it is repeatedly called in its popular pamphlets and bulletins and the government knows very well that no matter what happens it must produce the necessary raw material in the Donetz region if the railroads and factories still in operation in Russia are not to be condemned to shut down. But most of the large mines are drowned and under water and there are not large enough pumps to pump them dry. It is true that during the year 1920 four large pumps made in Switzerland had arrived in the region which had been laying in Archangelsk during the war and were distributed to some of the large mines but the installation was utterly fruitless because the necessary motors for driving them are non-existent. There are large quantities of motors around the mines but they all need repair and cannot be operated because the required insulating material and wire are non-existent. The works need gas and water pipe, boiler tubes and copper tubes; electrical equipment is not to be had. Wire cable is lacking. Everything which is necessary to maintain or to start operation is absent. On account of lack of wire cable the mine cages which were formerly operated in four stories only work in one or two stories which of course limits production considerably. Furthermore the mines originally need at least 3000 steam boilers inasmuch as the present boilers are absolutely useless. Never a week passes without a boiler explosion. In order to equip mines, the operation of which the government wishes to maintain, with the necessary boilers, boilers in good condition are taken from other factories and thereby those factories are immediately condemned to shut down. A so-called chock group of about 30 mines has been formed to which all available equipment is given and even that group does not obtain even 10 per cent of its requirements, although continually numerous representatives of the central administration, are hunting around everywhere in the Don region, in the Ukraine at Black Sea ports, to find mechanical equipment and to send more valuable material into the Donetz region. As far as the cost of production of the coal is concerned no correct calculation can be given because the prices of production equipment are simply fixed to suit by the requisitioning authorities. The machinery, of course, is not bought, but requisitioned from offices and factories; just like the boilers it is taken from one factory to be sent to another one the production of which is in most cases very questionable. Although Russia is so rich in large forets, the Donetz region is lacking the necessary lumber as well as mine timber. It is true that whole train loads of mine timber are sent from the region of Minsk and Pinsk but very few cars of these trains reach the Donetz region in filled condition, because most of it is stolen on the road. Of course, the quantity of produced coal is very insufficient in the event of this condition as the following table shows:

Produced Coal in Thousands of Pud of 35-Pounds Each.

Year 1920	Coal	Anthracite	Total
April	10,797	2973	13,770
May	13,857	4714	18.571
June	18,371	2184	25,555
August	15,522	7171	22,693

At the Same Time the Number of Men Employed Was in 1920

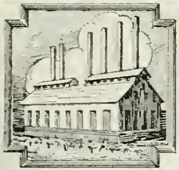
1920	Miners	Workmen below ground	Workmen above ground	
April	16.164	31,697	57,489	105,530
May	15,149	32,054	67,345	108.231
June	16,266	33,627	67,345	117.838
August	16,202	36,015	72,456	124,673

The government is conscious of the fact that the supply of foodstuffs for the rest of Russia depends upon coal production and that lack of coal will not permit them to export the grain from those parts of Russia where it is still plentiful. The government also endeavors to bring up the monthly coal production to 40,000,000 puds but this endeavor seems to be utterly hopeless with the present condition of organization and administration. The government will not have to make tremendous efforts to maintain the present rate of coal production. Since 1916 coal production has changed as follows:

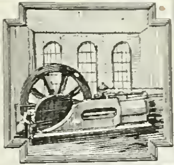
	1916	1917	1918	1919	1920
Reduction in Tons.	28,016	24.000	4.544	2,192	2,400
Average Monthly Production of Each Miner in Tons.	10,232	8,960	4,832	3,840	2.816
Number of Workmen.	126.000	114 000	94.000	57,000	110,000

The condition of the steel industry is still more hopeless than that of the mining industry. Almost all steel works are shutdown. The government cannot operate them on account of lack of fuel. The production of coal is too small to make any coke, and ore cannot be brought to the works on account of the sad conditions of transportation. Further there is lack of the necessary skilled workers and laborers. The skilled workers prefer to let the laborers do the work for them and lead an easy life as members of steel works committees and as incubants of responsible jobs without doing anything useful. But the laborers shirk hard work which does not even pay them enough to live and occupy themselves principally with profitable secret sales.

(Continued in May issue)



STEAM POWER DEPARTMENT



Development of Mechanical Soot Blowers

Recording Some Most Recent Tests of Mechanical Soot Blowers With Coal, Pulverized Fuel and Oil—Marked Increases in Boiler Efficiency Are Shown by Use of Mechanical Soot Blowers.

By ROBERT JUNE,
Mechanical Engineer.

THIS article records some of the most recent tests of mechanical soot blowers with coal, pulverized fuel and oil—marked increases in boiler efficiency are shown by the use of mechanical soot blowers with each of these fuels.

Soot, it has been stated, is the best heat insulator known, being more than five times as effective as asbestos in preventing heat transference. Those of us who have to deal with the soot problem continuously, know that this statement is literally true. You can no more expect efficiency out of a boiler, the fire surfaces of which are coated with soot, than you can expect efficiency from a man with a bad cold. There is congestion and bad circulation in both cases.

If you want to keep up steam when the soot piles up you will have to pile in more fuel. This fact has been strikingly illustrated in some recent tests. Mechanical soot blowers were installed on boilers fired with coal, pulverized fuel and fuel oil. These tests show clearly that clean tubes—clean as only mechanical soot blowers can make them—are absolutely essential to the maintenance of high boiler efficiency.

In this article then, instead of discussing advantages and disadvantages of mechanical soot blowers, questions which center in the design and construction of the equipment we will deal with some actual results secured in typical power plants, and will reserve our consideration of mechanical features and the types of equipment for different boilers until next month.

Test at Large Railroad Shop Boiler Plant — Soot Blowers Save $14,063.05 a Year.

During the winter of 1918-19 one of the big American railways decided that the cost of producing power at one of its large shops was excessive, and that the possibility of effecting a reduction through the medium of mechanical soot blowers should be thoroughly investigated.

Bigelow-Hornsby boiler No. 544, in the west boiler room which was selected for test, is rated at 625 hp. The stoker under the boiler is a Taylor 7-retort underfeed type, having a grate area of 105 square feet, with inclined grate. Forced draft was supplied to this stoker by 1 by 3-inch Sturtevant turbine-driven, multivane, double-inlet fans. In this test the forced draft and the stoker drive were separated and the stoker was driven by one of the Westinghouse engines recently installed on the boiler room floor for the driving of stokers. Induced draft was obtained by means of fans located at the uptake to the stack.

On boiler No. 544, steam flow was obtained by means of two meters, one an integrating-recording-indicating General Electric meter already installed and used in tests, and the other a newly-installed Bailey boiler meter. Weight of coal was obtained from the traveling weight hoppers and lorry tickets. A revolution counter was placed on the Taylor stoker to count the revolutions of the main power shaft. The thermometers for obtaining superheated steam temperature and that for obtaining feed water temperature, were placed in thermometer wells in their respective pipes at the top of the boiler as in previous tests.

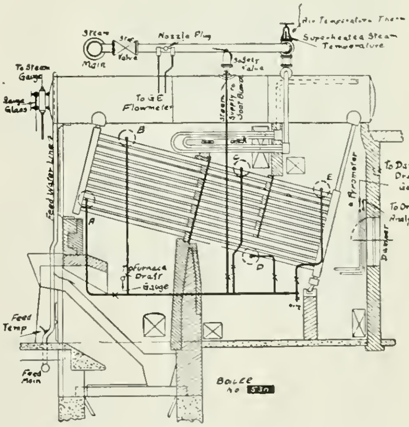


Fig. 1—Bigelow-Hornsby Boiler showing location of recording devices.

Uptake temperature was obtained from three pyrometers inserted into the flue above the damper, and inserted at 4, 5, and 6 feet respectively. The cold junction temperature was obtained by means of an indicating thermometer suspended over the cold junction of the pyrometers. Steam pressure was obtained from the steam gage in regular service in the drum. A steam correcting thermometer for obtaining the superheated steam temperature corrected was used. The carbon dioxide of flue gas was obtained by means of a sampling tube already installed and used in previous tests in conjunction with a standard Orsat gas analyzer. Draft over the furnace and at the damper was obtained on the indicated gage. Pressure in the wind box was indicated on the lower gage and on the recording pressure gage. In addition to the above, the Bailey meter indicated the draft over the furnace and the air flow through the boiler, the latter being obtained by means of two 1½-inch pipe connections, one to the combustion chamber over the furnace, and the other in front of the damper at the same height as the first. The various items indicated above, and constituting the testing apparatus of this boiler, are shown in the accompanying sketch.

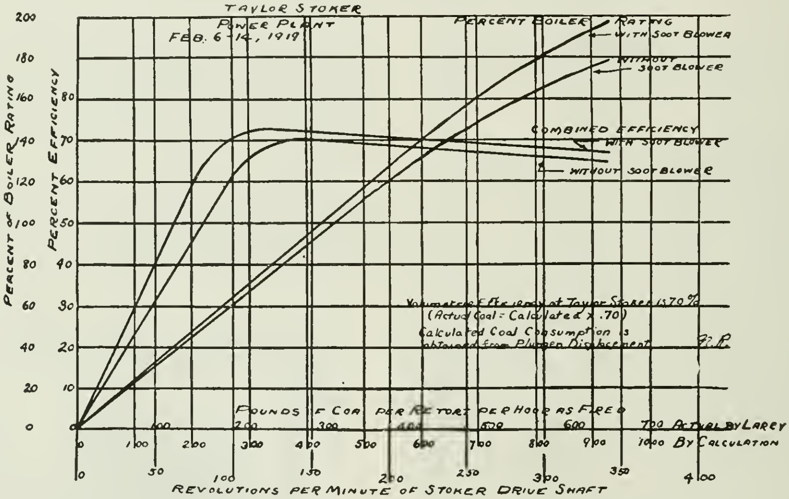


Fig. 2—Result of tests on soot blowers on Bigelow-Hornsby Boiler equipped with 7-Retort Taylor Stoker.

Boiler No. 544 was cut in on the line at 5 A. M., February 3, 1919. The duration of each run was 24 hours. At the beginning of each run the fire was cleaned whenever found necessary by observation of the fire. This varied from about 2 to 4 hours, depending on the load. On this boiler 8 tests in all were made, the first 4 being with soot blowers, and the second 4 being without soot blowers, attempting to reproduce the conditions of the first 4 as nearly as possible.

In doing this the fire-room crew and the tester were guided by the average conditions attained in the first 4 runs. Readings were taken every 20 minutes. The steam utilized by the soot blowers was not registered by the steam flow meters. Readings were taken as follows: steam flow; air flow; furnace draft gage; window-box pressure; the speed of the stoker line shaft; the number of revolutions of the stoker power shaft; steam on three pyrometers; cold junction temperature; air temperature; steam pressure, and carbon dioxide in the flue gas. Forced draft was obtained from No. 3 blower which was isolated from the other blowers by closing the division damper. It was kept running throughout the entire test, and the draft to the boiler was regulated by means of the control at the boiler.

A summary of the principal data and the results of the test on boiler No. 530 is given herewith as Table I. The same material has been tabulated for boiler No. 544, but as it does not differ materially, it is not here included.

Average value of the flue gas temperature for the series with soot blowers is 481.0 degrees F., against 569.0 degrees F. without soot blowers. This represents a decrease of 88 degrees using soot blowers and means that with the soot blowers in operation, the boiler has absorbed more heat from the gases, due to cleaner heating surfaces than without soot blowers.

It has been stated previously that with the present practice of cleaning the boilers with the hand lance, each boiler is cleaned every 4 or 5 days. In the tests on boilers No. 530 and No. 544 without soot blowers, in order to reduce this condition, the series was started with the boiler heating surface clean and then left without any cleaning during the series.

If the series had been extended for, say, an equal period or longer, and if during that period the regular hand method had been used to clean the boilers on the regular schedule, it is very probable that a still greater rise in flue gas temperature and still greater decrease in combined efficiency would have resulted. It is safe to say that a more exact test along the line indicated would show better results.

In addition to the above may be mentioned the fact that operation of soot blowers does not require the banking or shutting down of the boiler, while in

TABLE I.

Principal Data and Results of Tests on Babcock & Wilcox Boiler No. 530 With and Without the Soot Blower furnished by the Diamond Power Specialty Company.

Grate Surface of Roney Stoker (width 12 ft. 6 in., length 7 ft. 6 in.) Equals 94.5 sq. ft. Total Heating Surface (excluding Superheater) equals 5200 sq. ft.

	With Soot Blowers				Without Soot Blowers			
	Test No. 1	Test No. 2	Test No. 3	Composite No. 1 to 3 of Tests	No. 4 Test	No. 5 Test	No. 6 Test	No. 4 to 6 of Tests
1—Date started*	2-6-19	2-7-19	2-8-19	Feb 6 to 8	2-9-19	2-10-19	2-11-19	Feb 9 to 11
2—Duration, hours	24	24	24	72	24	24	24	72
3—Average steam pressure, lbs. per sq. inch gauge	187	187	186.5	......	187	187	189.0	......
4—Temperature of feed water, F. degrees	228	217	223	......	235	194.5	196	......
5—Average steam temperature, F. deg. corrected	425.3	419.3	421.0	......	427.3	436.7	445.5	......
6—Average superheat F. degrees	43.3	36.8	38.6	......	45.3	54.2	62.1	......
7—Average uptake temperature, F. deg. corrected	481	479	484	481.0	502.0	583.0	621.5	569.0
8—Average CO_2 per cent	10.9	11.8	12.8	......	10.4	11.5	12.0	......
9—Moisture in coal per cent	0.85	0.95	0.50	......	......	......	......	......
10—Total coal fired, pounds	43430	48070	58500	......	45105	55350	57540	......
11—Total coal dry, pound	43060	47613	58257	148880	44879.5	54918	56948	156746
12—Dry coal per hour pounds	1794.2	1984	2425	......	1870.0	2288.0	2373.0	......
13—Dry coal per sq. ft. of grate per hr. lbs.	19.08	21.1	25.8	......	19.89	24.35	25.25	......
14—Total actual evaporation lbs.	349080	412632	472968	......	381348	441504	427488	......
15—Factor of evaporation	1.061	1.069	1.064	......	1.055	1.102	1.107	......
16—Total equivalent evaporation from and at 212 deg., F. lbs.	370024	441102	503238	1314354	402322	486537	473229	1362088
17—Equivalent evaporation per hour from and at 212 deg. F. lhs.	15417.8	18379	20968	......	16763.4	20272	19718	......
18—Equivalent evaporation per hour from and at 212 deg. F. per sq. ft. heating surface, lbs.	2.96	3.53	4.03	......	3.22	3.89	3.80	......
19—Rated capacity per hour from and at 212 deg. F. lbs.	17940	17940	17940	(72 hrs.) 1291680	17940	17940	17940	(72 hrs.) 1291680
20—per cent of rated capacity developed per cent.	80.0	102.4	116.9	101.7	93.4	113.1	110.0	105.4
21—Equivalent evaporation from and at 212 deg. F. per lb. of dry coal lbs.	8.59	9.25	8.64	8.83	8.96	8.86	8.32	8.70
22—Heating value dry coal Btu per lb.	13572	14123	13840	13865	13731	14073	13996	13940

*Test No. 1 started February 6 at 9:30 A. M. Each succeeding test started one hour later in the day than the preceding one.

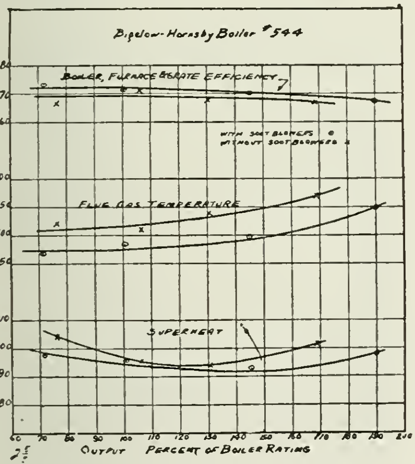


Fig. 3—Graphic summary of results attained by use of soot blowers on Bigelow-Hornsby Boiler.

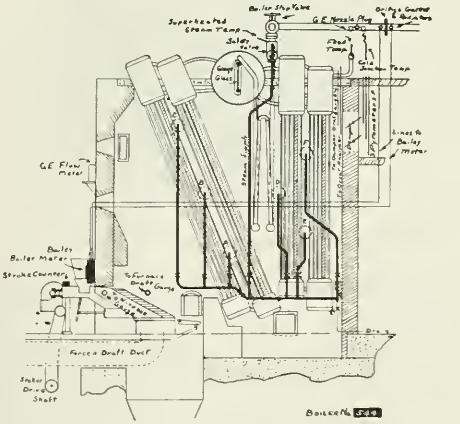


Fig. 4—Arrangement of soot blower units and recording apparatus on Babcock & Wilson Boiler.

order to remove the soot by the hand method it is necessary to shut down the boiler for two or three hours, during which time the boiler setting cools and must be warmed up again. Here is a loss which is eliminated by the use of soot blowers.

In conclusion it should be noted that these tests were conducted in a manner calculated to indicate a minimum rather than a maximum improvement by the use of soot blowers. The tests would undoubtedly have been fairer if the use of soot blowers before making the tests had been refrained from, employing the hand lance only to clean the boilers at the regular periods of cleaning. Had this been done, the boilers would not have had the advantage of being cleaned thoroughly by mechanical soot blowers when they entered the hand-hose test.

Mechanical soot blowers are just as important, just as necessary, with pulverized fuel as with other types. As a matter of fact, in practically all successful installations where pulverized fuel is used, the boilers are equipped with mechanical soot blowers. The tubes should be cleaned by the blowers every 6 hours or oftener. As the temperatures are high, the blowers should be constructed of some such material as calorized metal in order to withstand the hard service conditions. The regular use of mechanical soot blowers will save 4 to 8 per cent of fuel, as well as a large amount of the labor required for cleaning.

Soot Deposits In Oil Fired Boilers.

The soot deposit resulting from the combustion of oil is in the nature of a pure carbon mixed with a slight amount of oil. It is somewhat fluffy in appearance and adheres readily to the tubes, but is easily cleaned and removed from the boiler under the operation of a steam jet. It is entirely different in character from the soot resulting from combustion of coal on account of the absence of ash, etc., and the presence of greater or less quantities of unburned oil, which going through the boiler tend to deposit on the tubes in combination with the soot. If this formation is not removed at regular frequent intervals it soon crystallizes or carbonizes on the tube and must then be scraped off with rods or bars.

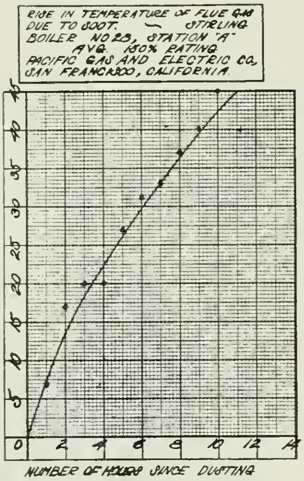


Fig. 5—Rise in temperature of flue gas due to soot.

Soot deposits from oil-fired furnaces have much greater insulating effect than those occurring with coal fired furnaces. There are two reasons for this: First of all, the deposit is in the nature of a pure carbon which has greater insulating properties than various ash constituents found in soot from coal; second, the deposit being of a somewhat fluffy adhesive nature, is usually found to envelope the entire tube as compared to coal deposit which usually consists of soot, dust and ashes building on top of the tube and leaving the underside more or less clean.

For some time after oil came into use for boiler furnaces, the impression prevailed that oil fired boilers did not require as frequent or as thorough cleaning as coal fired. The efficiencies of oil fired boilers were generally higher than those obtained where coal was used for fuel, due to more perfect combustion with a smaller quantity of excess air, and this improvement was for some time accepted on its face value as the best obtainable. With the increasing use of oil as fuel in the past few years, it was inevitable that detailed tests should be inaugurated of the performance of oil-fired boilers with and without mechanical soot blowers.

These tests developed the fact that mechanical soot blowers are absolutely essential to the development of the highest efficiencies on oil-fired boilers. As an example, attention is called to the results of the following test by the Pacific Gas & Electric Co.:

Test Data Before Using Soot Blower.

Time		Temperature	Load
A. M.	Stack	Sup. Steam	Meter
10:15	550	500	4.2
10:30	550	502	4.0
10:45	555	498	4.0
11:00	557	498	4.1

Test Data After Using Soot Blower.

Time		Temperature	Load
P. M.	Stack	Sup. Steam	Meter
2:30	485	495	4.2
2:45	485	506	4.0
3:00	482	504	4.3
3:15	483	505	4.2

Test Results	Before	After
Before	4.075	4.175
Per cent rating	101.85 percent	105.38 percent
Steam pressure gauge	199.5 lb.	200.75 lb.
Superheater steam temperature	499.5 deg.	502.5 deg.
Stack temperature	553 deg.	483.75 deg.

These results show that the soot blowing caused the temperature of the stack gases to fall from 553 degrees to 483.75 degrees, making a difference of 69.25 degrees or 13.05 per cent.

Also the temperature of the superheated steam was raised from 499.5 degrees to 502.5 degrees a rise of 3 degrees or 0.6 per cent.

The direct effect of the use of soot blowers is a saving of 3.9 per cent.

The Texas Company, Port Arthur, Texas, found a saving of 5.5 per cent fuel by the use of mechanical soot blowers and as a result ordered an equipment for 30 oil-fired boilers. As this company is in the oil producing business its action is particularly illuminating.

These tests were followed by others at some of the large western central stations. On one of these, the boiler, a large Stirling, was taken off the line, and the tubes, superheater, etc., washed clean. The boiler was then fired and an evaporation rate of 37,000 pounds of water an hour, and 14 per cent CO_2 was maintained. At the end of the 24-hours the soot blowers were operated, and were used for 24-hour periods for the remainder of the test with the equipment. During these tests, readings were taken at 15-minute intervals of the water-rate, CO_2, draft, oil and superheat. When using the blowers the flue temperature dropped to 525 degrees and rose to 540 degrees in about 15 minutes. It ranged around 540 degrees for about 16 hours, and then crept gradually up to 590 degrees at the blowing period, when it again dropped to 525 degrees. This was the regular daily performance throughout the test while using the blowers.

At the end of a 7-day period the boiler was given a final blowing and thereafter operated under the usual plant conditions; that is, without any cleaning at all. At the end of the first 24-hours' run, the temperature had risen to 590 degrees; at the end of the week it had risen to 680 degrees, and at the end of 10 days had risen to 720 degrees, at which point it seemed to hold. But they were not able to maintain the evaporation rate which dropped to 34,000 pounds an hour. The saving effected by soot blowers amounted to 6 per cent.

Despite the war emergency, with its constant urge to speed rather than to thoroughness, the Emergency Fleet Corporation made some detailed tests of Diamand Soot Blowers before adopting them. These tests were conducted at Burlington, Iowa, under the direction of the Bureau of Mines.

The boiler selected was the Foster Marine Water Tube, and was one of a large number then being built by the Murray Iron Works of Burlington, Iowa, for the Power Specialty Company of New York, for delivery to the corporation. The tests extended over a period of a number of weeks, and covered a wide variety of operating conditions, with boilers forced to high rating at times, with different conditions and drafts.

In addition to proving the necessity of soot blowers to economical operation, the tests threw some important light on soot blower construction. For instance, in boilers burning fuel oil, draft conditions are very low, running from .02 inches in the furnace up to .08 inches in the uptake. If soot blowers were designed so that all nozzles emitted steam at the same time, a curtain or blanket of steam would be ejected into the boiler at high velocity, with the result that it would either put out the fire or materially interfere with the draft. The bad effects of interfering with the draft can hardly be overstated. As a result of such conditions all of the factors in the operation of the boiler become unbalanced. This applies to the feed of oil to the furnace, the maintenance of even steam pressure, and the injection of the feed water. In place of a normal even operation, a condition of ebb and flow takes place which may last for an hour or more before conditions again become normal. Necessarily, this entails work on the part of the fireman who finds the whole routine and operation of the boiler room upset.

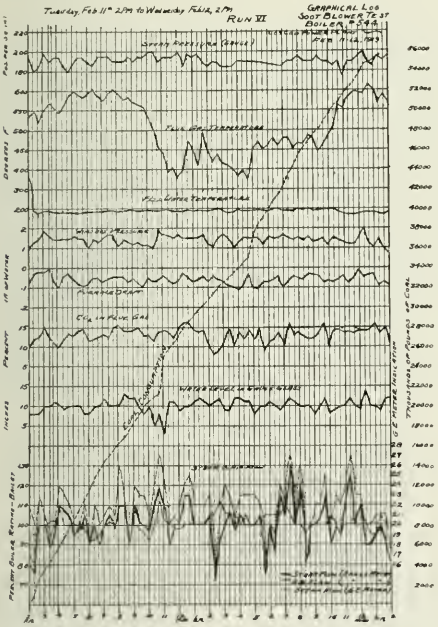


Fig. 6—Typical graph showing conditions test of soot blower.

In order to take account of this condition the soot blower for hollow-staybolt boilers is made up in vertical sections, each under the control of its individual valve. This arrangement permits of blowing three or four vertical rows of tubes at one time, thus avoiding all interference with the draft.

On stationary boilers of the horizontal water-tube type, vertically baffled, and on vertical boilers, where revolving soot blower units of the Diamond Model G type are commonly used, the use of fuel oil calls for little change in construction. Care is taken in locating the units to be sure that they blow with the draft. In addition, it is sometimes found advisable to stagger or offset the blower nozzles so that they do not all blow in the same direction at the same time.

As a result of the Burlington test, hundreds of oil burning vessels built by the Emergency Fleet Corporation were equipped with mechanical soot blowers. In conclusion, the mechanical soot blower for oil-fired boilers is here to stay, and the use of blowers on such boilers is fast becoming as common as the use of blowers on coal-fired boilers.

Table II.

Comparison of Composite Results With and Without Diamond Soot Blowers.

Decrease in average uptake temperature with soot blowers....	88 deg. F.	36.1 deg. F.
Percentage gain in efficiency of boiler furnace and grate with soot blowers	2.15%	2.05%
Value of savings of coal per year based on 1918 consumption and prices:		
In West Boiler Room..................		$ 8,559.86
In East Boiler Room..................		5,503.19
Total saving........................		$14,063.05

The exact effect of moisture in connection with spontaneous combustion is not known and the evidence of laboratory experiments is contradictory. The repeated wetting and drying of coal seems to increase the tendency to spontaneous combustion. This may be due to the breaking up of the coal which such alternate wetting and drying occasions, even if there is no chemical reaction between the water and the coal. It is not wise to put coal into a pile, or to store coal on a damp base if it can be avoided. After a rain or snowstorm a coal pile should be carefully inspected and watched.

Editor's Note—Due to an error in the composing room in making up the last issue of The Blast Furnace and Steel Plant, the photographs used in connection with the George T. Ladd's article on "Installation of World's Largest Boilers," were not placed in the article in the position corresponding to their mention in the text.

NEW CONTROLLING VALVE FOR OPEN HEARTHS.

(Continued from page 253)

do nothing to assist the proper mixing of the air and the gas.

The usual practice is to deliver the air and gas to one end of the furnace by separate flues, the air flue being directly over the gas flue. This arrangement is adopted with the idea that the difference in specific gravity will cause the mixing of the two. This result might be achieved were it not for the counteracting influences produced by the manner in which the air and the gas are brought to this point.

The gas is delivered from the producers at a pressure of approximately 1-inch W. G. The delivery of the air is solely dependent upon the amount of the stack draft, which must be maintained sufficiently high to draw the air through the valves checker chambers and flues. This draft pressure continues to exert its influence on both gas and air after the entrance to the furnace is reached, tending to draw them along in a straight line at a high velocity, thus preventing proper mixing. In order to overcome this counteracting influence, it is necessary to deliver the incoming air and gas to the furnace entrance at approximately the same pressure. The draft pressure could then be reduced until there is only sufficient to carry away the waste gases and attain a desirable flame-speed through the furnace. By this arrangement of forcing the air through the checker chambers better regenerating efficiency could be obtained and the present limitations in the design of regenerative chambers removed.

The difficulty of achieving this condition has been overcome by an ingenious arrangement in the form of a reversing valve combined with air-pressure and volume-controlling mechanism, for which applications for patent have recently been filled by W. H. Wharton, Consulting Engineer on steel plant equipment for Canadian Allis-Chalmers, Limited, Toronto.

A description of this valve, the method of operating together with illustration are given below:

Figure 1 is a plan of the complete valve and mechanism, one-half of the plan being shown in horizontal section, the whole plan being symmetrical about the centre line.

The valve chamber "A" consists of an arrangement of cast plates or other suitable construction, the same being brick-lined as to walls and roofing; the whole for the purpose of covering and separating the three different flues "B", "C" and "D", two of which, i. e. "B" and "C" lead in opposite directions to the two regenerative chambers situated one at either end of the furnace, the third flue "D" being connected to the chimney stack. These flues are separated by the partitions "E", "F" and "G", the partition "E" being made of a combination of brickwork and steel. The partitions "F" and "G" are hollow cast-sections filled with water. Each of these partitions "F" and "G" are constructed in such manner as to provide a seat for the valve when closed and to provide an opening for the easy passage of hot gases to the stack when the valve is open. Across this opening, pass four bent, hollow, tubes "H" all meeting in the centre of the opening, forming a hollow boss "J" which supports and connects the hollow shaft "K" to the four connecting tubes or arms "H". This hollow shaft "K" forms the valve stem upon which is supported part of the weight of the valve "N" and upon which the valve moves to and fro as operated. Another function of the hollow shaft "K" is to provide a means of conveying cooling water to the respective partitions "F" and "G" from which the water passes out by means of pipe "M", provided in a suitable location for that purpose.

The valve body "N" is made of cast iron, steel or other suitable material, suitably designed in order to impede the velocity of the air as little as possible, at the same time to offer the maximum surface possible to the cooling influence of the passing air. From the valve body "N" there is an extension tube "O" for the purpose of conveying and conducting the passage of the air chamber "P" through the valve into the respective flues "B" and "C". The tube "O" is connected by a hollow piston rod "Q" to the piston "R" which is operated back and forth in cylinder "W" by air or steam pressure.

The air-regulating device consists of two circular cones or valves "S" and "T" suitably connected and operated by the small piston "U" and connected thereto by the piston rod "V". On this piston rod "V" is fixed an adjusting wheel "Y" for the purpose of adjusting the length of travel of the air-regulating cones "S" and "T".

The operation of the valve is as follows:

Air is supplied at the required pressure to the air chambers "P". Water supply is connected to the ends of the hollow shafts "K". Air or steam pressure is admitted to opposite ends of the two cylinders "W", causing one of the valve bodies to be pushed forward into its respective valve seat and opening, at the same time admitting the air to the end of the tube "O" from the air chamber "P". At the same time, the pressure is admitted to the small cylinder "X" which operates small piston "U", thus pushing forward the two cones "S" and "T" to the required position, as determined by the setting of the adjustment wheel "Y". The reverse of these different operations is meanwhile placed on the other valve mechanism.

The exhaust pipes connected to each end of the two cylinders "W" are provided with a suitable cushioning arrangement to prevent shock at the end of each stroke.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

[Required by the Act of Congress of August 24, 1912]

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(Names and addresses of stockholders holding 1 per cent or more of total amount of stock.

Estate of H. A. Andresen, Care Colonial Trust Co., Pittsburgh, Pa.
Fred C. Andresen, 108 Smithfield street, Pittsburgh, Pa.
L. L. Carson, 108 Smithfield street, Pittsburgh, Pa.
R. H. Thiess, 108 Smithfield street, Pittsburgh, Pa.
M. M. Zeder, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

FRED C. ANDRESEN, Business Manager.

Sworn to and subscribed before me this 21st day of March, 1921.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1923)

FOREIGN RELATIONS

THE IRON ORE MARKET OF BILBAO IN 1920.

A recent article in Informacion, the official organ of the chamber of commerce of Bilbao, states that the ore market at that place during the year 1920 was very satisfactory and brought significant profits to the mine operators in spite of high prices of coal and labor difficulties which prevailed throughout the greater part of the year. England has been the chief destination of the exports during the past year, as the French and Belgian markets have absorbed only small amounts. Toward November the exports to Germany showed a slight increase. It is noted that the exports for the year 1920 amounted to 2,104,545 tons, as compared with 1,513,997 tons during 1919, and 2.253,428 and 2,072,519 tons during 1918 and 1917, respectively. Stocks of ore on deposit in December, 1920, amounted to 650,000 tons, being a decrease from the 780,000 tons in December, 1919. The stocks on hand at the same period of 1918 and 1917 are reported as 300.000 and 690,007, respectively.

EXPORT TAX ON VANADIUM.

By J. H. Roth, Vice Consul, Callao, January 21, 1921.

A law has been passed by the Peruvian Congress and signed by the President on January 19, 1921, whereby a tax of 45.29 sols per metric ton of 2,204.6 pounds will be levied upon all vanadium exported from Peru. This tax will be in force until December 31, 1921. [Sol = $0.468, normal value.]

NEW PHOSPHORUS MINE PURCHASED BY GOVERNMENT STEEL WORKS.

It is reported, states the Far Eastern Review, that a large phosphorus mine, located on Taisho Islands in Okinawa Prefecture estimated to contain 15,000,000 tons of rock containing 28 per cent of phosphorus and recently discovered by Mitsui engineers, is to be purchased by the Government steel works at Yawata in preference to importing supplies from abroad.

GRAPHITE MINE DISCOVERED IN LAIYANG SHANTUNG.

A deposit of graphite suitable for use in making pencils has been discovered near the northwest village of Laiyang, Shantung, states Millard's Review, by Japanese interests. The Laiyang mining administration is said to be taking up an investigation of the deposits, which are extensive.

IRON MINING IN ALGERIA.

The Ouenza Iron Mining Company has just finished the construction of a railroad connecting its property with the line running from Tebessa to Souk-Ahras at a point about midway between these two stations. The length of the new branch is 24.41 kilometers (about 14¼ miles). Ore may now be transported by railway directly from the mine to Bona, the port of embarkation.

The Rouina Iron Mine Company has just increased its capital from $1,686,750 to $2,895,000 for carrying out an important program of expansion. The new work is to include installation of a hydro-electric plant at the mine and one for the town of Philippeville, improvement of loading facilities at Philippeville, and building of workers' houses. The company hopes, by these means, to increase its output above the present 7,000 metric tons per month and to lower cost of production. Labor is easily obtainable in the region.

MARKET FOR AMERICAN COKE DUST IN CZECHO-SLOVAKIA.

Trade Commissioner Geringer of Prague, states that a large manufacturer of Portland cement who uses coke dust in the manufacture is desirous of receiving quotations on American coke dust in shipload quantities. It is necessary that the dust come from the best quality of coke. Further information might be obtained from the European Division, Bureau of Foreign and Domestic Commerce.

GERMAN FIRM OBTAINS CONTRACT TO SUPPLY ARGENTINE RAILROAD WITH CAR WHEELS.

A cablegram received from Commercial Attache Feely, Buenos Aires, dated March 1, 1921, states that the Krupp interests in Germany have obtained the contract for the 10,000 car wheels desired by an Argentine railway.

PEAT PROVES SATISFACTORY FUEL ON SWEDISH RAILWAYS.

Tests extending over several months have passed the experimental stage and conclusively demonstrated that peat, reduced to powder or prepared in the form of briquets, makes an excellent substitute for coal as fuel for locomotives. The Railway Board of Sweden, satisfied with the results of these long-continued tests on the State railroads, has recently taken over the specially constructed plant at "Haesthagen" bog, near Vislanda, with a capacity of 30,000 tons per annum and which cost 975,000 crowns ($261.300 at normal rate of exchange. An entirely new method of treating peat on a large scale has been adopted. All the machinery in use, invented and constructed by the engineer in charge, Mr. Ekelund, appears to be so well adapted for the purpose that the conversion of peat into a cheap and effective fuel requires only a small working force. The peat is dried in the open air as far as possible. Only the hardest and driest lumps are used for ordinary fuel, the remainder being converted into powder or briquets. The plant was originally intended for the manufacture of peat powder only, but it was found that briquets were as well adapted for fuel, hence both are now being made. The discovery was also made that powdered peat becomes a dangerous explosive when subjected to high temperature.

AUSTRIAN ARMS FACTORY MANUFACTURING AUTOMOBILES.

The works of the Austrian Arms Manufacturing Company (Oesterreichische Waffenfabriksgesellschaft) in the city of Stepyr, Upper Austria, are now manufacturing high-grade six-cylinder passenger automobiles and trucks by a new method. The end of the war found them with an equipment capable of producing 1,000,000 rifles and other small arms per year. Now they are making a few sporting rifles of the "Mannlicher" model, and shotguns. During the war the works employed about 15,000 men; they now have about 6,000. Thus far the company has produced about 400 automobiles; it expects to produce 4,000 in 1921 and 10,000 in 1922, and to increase after that to 20,000 machines per year. It is said that the automobiles are in great demand, and are now sold in England, France, the Netherlands, Germany, Poland, and Rumania.

NEWS OF THE PLANTS

Gilbert T. Sugden and Charles F. Magoffin, both of Buffalo, N. Y., have organized a new company to take over the rolling mills of Westerman & Co., Lockport, N. Y., manufacturers of rolled iron products. The new company will take immediate possession and, it is reported, will make a number of extensions and improvements in the plant at a later date. The present capacity is about 9,000 tons of material per annum, including such specialties as screw iron, squares, hexagons, rounds, etc.

The Manitoba Rolling Mills, Selkirk, near Winnipeg, Man., has commenced production at its new local blast furnace, said to be the first open hearth plant in this province. The plant comprises a 15-ton furnace, three 15-ton ladles, molds and other equipment. The plant is electrically operated, power being received from the hydroelectric generating plant at Winnipeg. The new plant represents an investment of close to $1,000,000.

The Chester Iron & Foundry Co., Vulcan avenue, St. Louis, Mo., has awarded a building contract to John Dougherty, St. Louis, for the erection of a one-story addition to its plant, 50x100 feet, to cost about $30,000. E. A. Linnis is secretary of the company.

The Inland Steel Company, Chicago, Ill., with mills at Indiana Harbor and Chicago Heights, has completed the erection of the building to be used for its 28-inch mill. The structure consists of an extension to a former building, 90x560 feet, and will be fully equipped for all features of operation. The company has recently increased the plant capacity by changes and improvements. The sheared mill has been changed from a 90-inch to 100-inch plant, and one stand of additional rails has been installed. The work will be divided between roughing and finishing. A new powdered coal plant has been completed and will be placed in service at an early date. The company has abandoned a rolling mill project which it contemplated some months ago.

The American Steel & Wire Co., Grove street, Worcester, Mass., has taken bids for the superstructure of its proposed new plant addition, foundation work for which is now in progress. The structure will be three-story, 120x145 feet, and is estimated to cost about $150,000 with machinery. It will be used for increased production in certain departments.

The Kokomo Steel & Wire Co., Kokomo, Ind., is completing plans for the rebuilding of the portion of its steel plant, recently destroyed by fire. The Indiana Bridge Company, Muncie, Ind., has received the contract for the steel work in connection with the rebuilding. The new structure with machinery is estimated to cost about $300,000.

The Atlas Steel Wheel Company, Rockefeller Building, Cleveland, Ohio, has plans under way for the erection of an addition to its wheel works on Lincoln road for increased capacity. The structure will be one-story, brick and steel, and is estimated to cost about $100,000 including machinery. It is proposed to commence construction at an early date. H. F. Arndt is president.

The Bethlehem Steel Company, Bethlehem, Pa., has work under way on a number of improvements at its plant at Sparrows Point, Md. The extensions will include a four-hole soaking pit furnace for the 40-inch blooming mill, with an extension about 200 feet long to the billet and sheet bar storage runway at the blooming mill section. An extension is being constructed to the ore unloaders and other improvements made in this department to facilitate operations. Coal crushers will be installed for the gas producers at the No. 2 open hearth plant at the 40-inch blooming mill. A considerable portion of this work is expected to be completed at an early date, and will be placed in service as soon as operations require. A number of smaller improvements are also under way at the mills to increase the general efficiency of the works.

E. L. Magill, 60 Devore street, Brooklyn, N. Y., manufacturer of steel products, is arranging for the erection of a new one-story plant on Atlantic avenue, to cost about $50,000.

The Batavia Car Works, Inc., Batavia, N. Y., manufacturer of steel and iron railroad equipment, has awarded a building contract to John Lennon & Co., Batavia, for the erection of its proposed new plant on a local site. The works will cost about $350,000, including machinery. John Baskat is president.

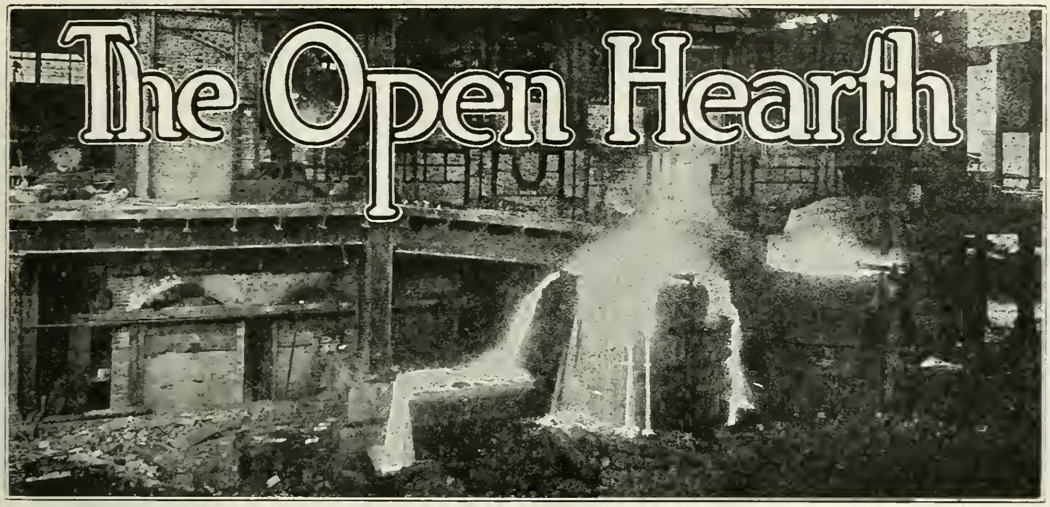
The Electric Steel & Forge Co., Grant avenue, Cleveland, O., has plans under way for the erection of a new steel rolling mill addition at its works. The structure will be one-story, and is estimated to cost in excess of $300,000 including machinery. J. H. Harron & Co., 1360 West Third street, Cleveland, are architects and engineers for the project.

The Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., is making substantial progress in the erection of a new fabricating plant at Fairfield, Ala., to be operated in conjunction with its steel plant at this point. The new works will be used for steel shape production for ship and car material, and is estimated to cost in excess of $1,000,000. The company is also making additions to the finishing department at its bar mills, and similar extensions will be made to the structural and plate mills. At its Ensley, Ala., works, the company has been making a number of minor improvements, including a dry gas cleaner for one of the blast furnaces at this point.

The William H. Beers Company, Park Row Building, New York, iron and steel construction, is developing plans for standardized building construction of all-steel type. The company's system will allow for the erection of buildings of various shapes and sizes under one basic system, bringing the greatest possible economy and efficiency in manufacture and erection. At a later date it is proposed to establish a steel plant for the production of the material, as well as for other iron and steel specialties of rolled section and built-up steel type. The company is headed by William W. Beers and S. F. Tapman.

The Sterling Steel Foundry Company, Eighth street, Braddock, Pa., has preliminary plans under way for the rebuilding of the portion of its works recently destroyed by fire; loss estimated at $75,000.

The Open Hearth



Theodore S. See has resigned his position as Assistant General Superintendent of the Jones & Laughlin Steel Co., Pittsburgh, Pa., and has organized an industrial engineering company with offices in the Oliver Building. Mr. See has been with the Jones & Laughlin Steel Co. for 12 years, having joined the company as production engineer at their Keystone Works. Later he became superintendent of the structural plant. He was rewarded for his successful management of the structural department by being made assistant general superintendent of the entire Pittsburgh plant. Here as head of the efficiency department he also applied his original and productive ideas to the open hearth and steel works. He has been unusually successful in installing practical production systems which have resulted in phenomenal increases in tonnage with corresponding reductions in costs. Mr. See was with the Riter-Conley Company for four years previous to his connection with the Jones & Laughlin Steel Co. As a token of the high esteem in which Mr. See was held, the superintendents and employes presented him, upon his resignation, with a suitably engraved gold watch. Mr. See is a member of the American Society of Mechanical Engineers and the Engineers Society of Western Pennsylvania.

V V

F. J. Griffiths, vice-president and general manager of the Central Steel Company, Massillon, Ohio, was elected a member of the board of directors and vice-president of the Massillon Rolling Mill Company, Massillon, at the recent annual meeting.

V V

Edgar C. Felton, a former president of the Pennsylvania Steel Company, Steelton, Pa., was elected a director of the Pensylvania Railroad, succeeding A. W. Mellon, who resigned owing to his appointment as Secretary of the Treasury.

V V

H. W. Torney, New York, was elected president of the Sharon Pressed Steel Company, Sharon, Pa., at a recent meeting of the directors, and succeeds Mr. J. D. Corcoran, who served as president for the past year. Mr. Torney is head of Torney & Co. and association with J. S. Pardee & Co., bankers of 66 Broad street, New York. A. W. Morris was elected vice-president in charge of sales, while A. F. Swan, who was formerly chief engineer of the Crucible Steel Company of America, at its Harrison, N. J., plant, will be in charge of operations. Mr. Torney has assumed his duties with the company.

V V

At the recent annual meeting of the Wellman-Seaver-Morgan Company, Cleveland, three new directors were added to the board, these being Arthur G. McKee & Co., George W. Burrell, vice-president and works manager of the company, and A. G. Tame, vice-president of the Cleveland Trust Company.

V V

Roger M. Freeman has gone into business for himself as construction engineer, with headquarters at 8 West Fortieth street, New York. Mr. Freeman had charge of the design and construction of the armor plate and gun forging plant for the navy department at South Charleston, W. Va. As supervising engineer for the navy, Mr. Freeman was in charge of the construction and design of the Erie Forge & Steel Co., Erie, Pa.; the forging plant of the Pollak Steel Company, Cincinnati; and the heat-treatment plant of the Allis-Chalmers Company, Milwaukee.

V V

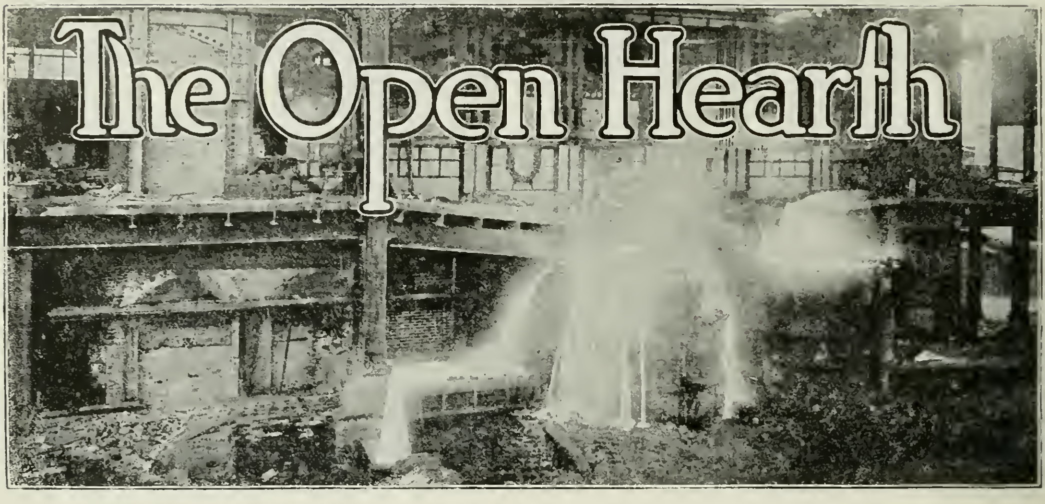
R. J. Emerich, secretary and treasurer of the W. W. Sly Manufacturing Company, Cleveland, has been elected president and general manager succeeding the late W. C. Sly. George P. Steel as treasurer and S. C. Vessy as secretary succeed Mr. Emerich. George J. Fanner continues as vice-president and, with the other officers and Paul Ryan, constitutes the board of directors. L. Bottomley succeeds the late G. K. Fanner as superintendent. Mr. Sly and Mr. Fanner were killed defending the company's payroll from bandits, December 31, 1920.

V V

R. M. Marshall has been appointed general manager, Leon A. Ehrman superintendent of blast furnaces and H. Frank Shaffer, general master mechanic of the American Manganese Manufacturing Company, Dunbar, Pa. Mr. Marshall formerly was superintendent of blast furnaces, Mr. Ehrman formerly assistant superintendent of furnaces and Mr. Shaffer formerly furnace master mechanic, all of the Midvale Steel & Ordnance Co., Coatesville, Pa.

V V

Andrew W. Mellon, who has been appointed secretary



The Open Hearth

of the treasury by President Warren G. Harding, in addition to being head of the Mellon National Bank, Pittsburgh, is prominently identified with a large number of industrial corporations connected directly or indirectly with the iron and steel industry. He has resigned as director in the following companies: Aluminum Company of America, Aluminum Ore Company, American Locomotive Company, Baltimore Car & Foundry Co., Butler Bolt & Rivet Co., Butler Car Wheel Company, Carborundum Company, Crucible Steel Company of America, Forged Steel Wheel Company, Koppers Company, McClintic-Marshall Company, Middletown Car Company, McClintic-Marshall Construction Company, Minnesota By-Product Coke Company, Pittsburgh Coal Company, Pittsburgh Model Engine Company, Pressed Metal Radiator Company, Riter-Conley Company, Riter-Conley Manufacturing Company, Seaboard By-Product Coke Company, Standard Motor Truck Company, Standard Steel Car Company, Steel Car Forge Company, Union Shipbuilding Company, United States Aluminum Company, and the Verona Steel Castings Company.

√ √

Chairman E. H. Gary of the United States Steel Corporation, is to sail for Europe in the very near future, presumably in connection with the proposed organization of an international association of steel-makers. At a recent meeting of the directors of the American Iron and Steel Institute, Judge Gary was empowered to direct his efforts toward the carrying out of this plan.

√ √

J. M. Flood has been promoted to assistant master mechanic at the Youngstown Sheet & Tube Co.'s Youngstown Plant.

√ √

N. Price Whitaker, secretary Whitaker-Glessner Company, a subsidiary of the Wheeling Steel Corporation, has been mentioned as a possible Assistant Secretary of War.

√ √

T. W. Oberhauser, who was appointed Pittsburgh district sales manager of the Wheeling Steel Products Company recently, sales subsidiary of the Wheeling Steel Corporation, for the past three years, has served in a similar capacity for the Wheeling Steel & Iron Co. Before joining the sales organization of the latter Mr. Oberhauser had been with the Crane Company, Chicago, for about 10 years.

√ √

E. J. Wood, formerly in the works management department of the Westinghouse Electric & Mfg. Co., for six years before the war, is now manager of the factory control department of the Columbian Enameling & Stamping Co. at Terre Haute, Ind. Before going to the enameling plant, Mr. Wood was doing industrial engineering and accounting work at the Firestone tire and rubber plant in Akron, Ohio.

√ √

At the annual meeting of the stockholders of the Jackson Iron & Steel Co., Jackson, Ohio, all the old board of directors were re-elected. The board re-elected the following officers: President, Simon Labold; vice-president, D. D. Davis; secretary-treasurer, J. F. Morgan; general manager, Noah G. Spangler; superintendent, O. O. Laudig.

√ √

Richard Trimble, secretary and treasurer of the United States Steel Corporation, who has been seriously ill for the last few days, is improving materially.

√ √

H. W. Torney, head of Torney & Co., New York, has been elected president of the Sharon Pressed Steel Company, Sharon, Pa., succeeding J. D. Cochran.

√ √

Charles Taggart, for 20 years foreman of the finishing department of the National Malleable Castings Company's plant, Sharon, Pa., has resigned to become associated with the Dominion Foundries & Steel Co., Hamilton, Ont.

√ √

Louis Muench has retired from active service as manager of the Republic plant of the Vulcan Detinning Company, Neville Island, Pa., retaining his interest as stockholder and director. R. D. O'Neil, who for a number of years has been superintendent, succeeds Mr. Muench as manager.

√ √

James Arnold, recently appointed director and general manager of the Canadian Foundries & Forgings, Ltd., was formerly assistant manager at the plant at Brockville, Ont. He was at one time a resident of Montreal in connection with the hardware trade and during the war served with the imperial munitions board. He is also vice-president of the Mann Axe Company, Ltd., St. Stephen, N. B.

WITH THE EQUIPMENT MANUFACTURERS

PRESSURE-OPERATED SWITCH OF UNUSUALLY COMPACT DESIGN.

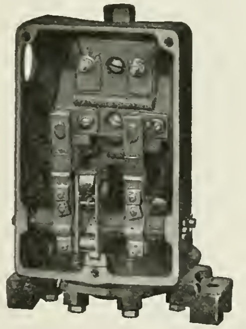
A pressure regulator of the diaphragm type, which has recently been developed by The Cutler-Hammer Manufacturing Co. of Milwaukee, Wisconsin, is much more compact and simpler in design than the other C-H diaphragm type regulators. This new device which is known as Bulletin 10004, is arranged for easy mounting, and its three overall dimensions are 6, 6½ and 8 inches. It is used with motor-driven pumps or compressors controlled by a main line magnet switch or some other suitable automatic starting device. It has two poles, which enables it to be used also for connecting small A. C. and D. C. motors directly to the line.

New C-H pressure-operated switch for automatically controlling motor-driven pumps and compressors.

The air, water, or other fluid under pressure is conducted into a chamber in the base of the regulator, and the pressure acts against a rubber diaphragm and compresses a spiral spring, the normal compression of which can be changed by means of an adjusting nut to obtain various values of opening pressures up to 60 pounds per square inch. When the switch is closed and the pump or compressor operating, the pressure builds up, and when the adjusting spring has been compressed to a certain point, the switch snaps open and stops the motor. When the pressure has fallen to a predetermined point, the switch closes with a quick action, and the pump or compressor again operates to build up the pressure system.

This snappy make-and-break action of the switch is accomplished by an arm carrying a roller which is held in tension against a cam mounted on the operating shaft of the switch. The movement of the adjusting spring is transmitted to the roller which moves along the surface of the cam. When the opening or closing pressure is reached, the roller passes a peak on the cam, and gives the latter a quick turn, thereby opening or closing the switch. A good contact pressure is maintained up to the instant the switch is opened. The difference between opening and closing pressures is about 20 pounds.

The entire mechanism of the regulator is enclosed in a cast iron case arranged for the entrance of conduit. Terminals and fingers are exposed by taking off the cover of the case. which necessitates only the removal of three screws.



Cover removed, showing interior construction of switch.

The regulators are at present made for 60 pounds maximum service, and it is expected that they will shortly be provided for use on systems up to 200 pounds pressure with few slight modifications in design.

RIVET CUTTING RECORD.

What is believed to be the record to date for cutting rivets in the dismembering of steel freight cars was recently established by an operator who cut out 1,038 rivets in 2 hours and 46 minutes. Of this number 683 were ⅝-inch rivets, 288 were ¾-inch rivets, and 127 were ⅞-inch rivets.

The cutting was done on a standard Erie car under general yard conditions, the operator taking the rivets as they came, working inside, outside and under the car. The car was one that had been retired from active service and that was in the car shop for repair, the rivets and plates being covered with heavy scale and rust, thereby rendering the cutting extremely difficult.

It is said that the record applies not only to the number of rivets cut in the time required but also to the low consumption of gases used, the job taking only 384 cubic feet of oxygen and 83 cubic feet of acetylene. The operator used an Oxweld cutting blowpipe with a rivet cutting nozzle.

SLAG POCKETS FOR OPEN-HEARTH.

The removal of slag from chambers after a run, or in case the furnace has broken out causing both slag and metal deposited in slag pocket to be broken up and carried to dump or skull cracker, whichever the practice of that particular plant demands, has always been a tedious and trying task for both men and superintendent.

With the design of slag chambers of ample width, due to the gas and air passageways to furnace ports from checker chambers and height below discharge ports of checker chambers at furnace uptakes, the volume of slag that can, under normal conditions of furnace operation, be carried until the period of general repairs are to be made, is sufficient so that no occasion would require the shutting down of the furnace unless a break or unforseen bath condition would force down the uptake flues and deposit into these chambers excess slag and metal that ordinarily is discharged at the trough from the furnace at the end of a heat.

The use of the older methods of slag removal which means, to tear away the entire front wall and with the aid of picks, wedges, bars and not to mention the confined quarter for men at all times, and hot work during the summer months—has caused at times a demand from laborers of an increase in pay before they would work under these conditions; or with the aid of slag guns using fewer men and getting the slag out quicker, which still requires days under the best of working conditions, has, within the past few years, brought out the feasibility of making a water cooled pocket, which would set the slag as quick as its heat would penetrate the wall and into the jacket or pipes of cooling water or with the aid of chill plates outside a thin wall cause the slag to set quickly. The contraction of the slag was depended upon to free itself from the side walls and therefore in case of removal be easier to dig out.

The Whalen Removable Air-Cooled Slag Pocket is an item of but small expense to insert as old beams, rails, rods and plates can be used and it does not require special piping, buckstays, cooling plate, etc.

TRADE NOTES

Dwight P. Robinson & Co., Inc., a large firm of engineers and constructors of New York, has recently opened branch offices in Montreal in the Dominion Express building. Alexander C. Barker, vice-president, is in charge of the office. The company is a consolidation of Westinghouse, Church Kerr & Co., Inc., and Dwight P. Robinson & Co., Inc., and has done extensive construction and engineering work in Canada for the Canadian Pacific Railway, Canadian Salt Company, Canadian Crocker-Wheeler Company, Dominion Government, Aetna Explosives Company, Grand Trunk Railway and others.

The appointment of Mr. J. B. Crane to the sales and engineering department of the George T. Ladd Company, manufacturers of the Ladd Water Tube Boiler, has just been announced. Mr. Crane has had over 15 years' experience in the construction and operation of power houses and has a wide acquaintance among the public utilities, engineers and mining men in various parts of the country.

The Pittsburgh office of the Independent Pneumatic Tool Company, was moved on February 26, from the old address of 1208 Farmers Bank building, to 718 Bessemer building, corner of Fort and Duquesne Way, Pittsburgh, Pa.

The Midvale Steel & Ordnance Co. have placed an order with Arthur G. McKee & Co., Cleveland, covering the furnishing of a McKee revolving distributor for their No. 1 furnace at Coatesville, Pa. This makes a total of 124 McKee revolving distributors in operation or under construction.

The Blaw-Knox Company of Blawnox, Pittsburgh, Pa., with branch offices in the largest cities from coast to coast, is now entrenching itself in the South. Having but recently established a district sales office in Birmingham, Ala., the company on April 1 opened up a new sales territory in the Southwest, with headquarters in Kansas City, Mo. In addition, the Blaw-Knox Company has sales offices in New York, Chicago, Detroit, Boston, Baltimore, San Francisco and Sheffield, England.

Grindle Fuel Equipment Company hereafter will be the name of the Powdered Coal Company, formerly known as Combustion Economy Corporation. The capital stock has been increased to $1,000,000 in Illinois, and the company is having plans prepared for building a manufacturing and demonstrating plant, to consist of a foundry, machine and sheet metal shop, office and engineering department, a complete powdered coal preparation plant, and other departments necessary for the manufacture of powdered coal equipment. The complete plant will utilize powdered coal for fuel, and conveying system and firing equipment of the company's manufacture will be installed.

The Electric Furnace Construction Company, 908 Chestnut street, Philadelphia, announce that they have closed a contract for a large electric heat-treating furnace with the Yale & Towne Mfg. Co., Stamford, Conn.

Messrs. H. A. Greaves and H. Etchells have recently been granted a new patent on a 3-electrode electric melting furnace. These patents are controlled by the Electric Furnace Construction Company, Philadelphia.

The steady increase in business of the Conveyors Corporation of America, formerly American Steam Conveyor Corporaiton, Chicago, has necessitated doubling the number employed in their South Bend, Indiana plant. The Conveyors Corporation manufacture the American Trolley Carrier and the American Steam Ash Conveyor.

TRADE PUBLICATIONS

The Griscom-Russell Company have issued Bulletin No. 315, describing the G. R. Multiscreen Filter, a redesign of the famous Reilly Feed Water Filter and Grease Extractor.

The American Roller Bearing Company have issued Bulletin No. 1005 which fully describes the Type "C" Roller Bearings made by their Company. Included are photographs of machinery showing where these roller bearings have been installed. It also mentions the engineering coöperation which the company is always ready to furnish.

The Bacharach Industrial Instrument Company of Pittsburgh, Pa., have just issued a folder showing their new quarters, a handsome brick building of 18,000 square feet floor space at Homewood Station, Pittsburgh. The additional space which they have acquired by the purchase of this building has increased considerably their facilities in giving prompt and efficient service to their customers. The products handled by the company are given on page two of the folder and consist mainly of gas meters, air meters, pressure recorders, draft recorders, pitot tubes and orifices, CO_2 indicators, manometers and engine indicators.

A new departure in combustion control devices is described in an illustrated bulletin recently issued by the Mono Corporation of America, 25 West Broadway, New York City. The Duplex Mono, as it is called, is unique in that it automatically analyzes and records the combined percentages of three combustible gases (CO, CH_4, and H_2) during all such times as any or all of these appear in the flue, while it also produces a continuous accurate record of the percentage of CO_2.

George J. Hagan Company of Pittsburgh, Pa., have recently issued a booklet covering the Hagan hand-stoked gas producers. These producers are built for economical and efficient production of bituminous producer gas and there is no question but what they will live up to the reputation of the other Hagan products. The booklet explains the characteristics of the gas produced, description of the producer, and general information regarding the various fuels which can be used in the producer. It also contains some line drawings of the producer.

Anderson Visible Pump & Tank Co., Savannah, Ga., is circulating a 6-page illustrated folder in which quick delivery, self-measuring gasoline pumps, as well as tanks, oil and gasoline storage systems, etc., are described and illustrated.

The Hill Clutch Company, Cleveland, is circulating a 4-page illustrated bulletin in which transmission machinery in a modern oil refinery is described and illustrated. The information given is interesting and valuable.

The Seybold Machine Company, Dayton, O., is circulating an illustrated booklet of 16 pages, in which various parts of the company's plant are described and illustrated. The booklet is entitled "A Trip through the Plant of the Seybold Machine Company." This plant is said to be one of the largest in the world devoted exclusively to the manufacture of machinery.

COMING MEETINGS.

April 21-23—American Electrochemical society. Spring meeting at the Hotel Chalfonte, Atlantic City, N. J. Joseph W. Richards, Lehigh university, Lehigh, Pa., is secretary.

May 5-6—British Iron & Steel Institute. Spring meeting at the Institution of Civil Engineers, Great George street, London, S. W. 1. The secretary is Geo. C. Lloyd, 28 Victoria street, London, S. W. 1.

May 9-10-11—American Association of Engineers. Annual convention to be held in Buffalo. National association headquarters, 63 East Adams street, Chicago.

May 19-20 — National Machine Tool Builders' Association will hold its spring convention at Hotel Traymore, Atlantic City, N. J.

May 23-26 — American Society of Mechanical Engineers. Spring meeting, Congress hotel, Chicago. Calvin W. Rice, 29 W. Thirty-ninth street, New York, is secretary.

June 22-26—American Drop Forge Association. Annual meeting will be held in Chicago. E. B. Horne, 1516 Helen avenue, Detroit, is secretary.

September 19-24 — American Society for Steel Treating. Annual meeting will be held in the Manufacturers' Building, State Fair Grounds, Indianapolis. W. H. Eiseman, 4600 Prospect avenue, Cleveland, O., is secretary.

The Blast Furnace and Steel Plant

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Control of Temperature in The Acid Bessemer Blow

The Methods for Raising the Temperature Are Considered in Detail—Means for the Control of Temperature Stated Collectively and Described.

By HENRY D. HIBBARD

IN the Bessemer process the importance of having the proper temperature of the charge throughout from start to finish, is well known, but the reason or reasons for such regulation is only partially known. The range of temperature must be between the point, on the low side, that will keep the metal and slag sufficiently fluid and the point on the high side that will permit or cause the chemical reactions of the process to take place in their proper order and manner. Control of the temperature also enables the gases to be dealt with correctly, so that they shall be within an allowable maximum in quantity, if solution or killed steel is being made, and in ample supply if the product is to be low-carbon effervescing or "rimming in" steel. The temperature of dissociation of the silicon oxide must not be reached, on the high side, for if that occurs the silicon will not be wholly oxidized and the residual silicon will be high and uncertain in amount, that is, anything up to 1½ per cent, while the drop of the carbon flame at the end will be obscure and difficult to determine. In such steel the gases cannot be controlled and the ingots or castings are likely to be infested with gas holes. The casting temperature in particular must be right within narrow limits; the ideal degree for most ingot steels being that at which the steel may be cast cleanly into the molds, with the formation of an embryo skull left in the ladle, the smaller the skull the better, but in any case not large enough to cover the ladle bottom. For steel castings the steel should be hotter and leave no skull.

The normal course of temperature for a Bessemer blow is only to be learned by experience. Indications come early in the blow, during the first period, when the silicon is being burnt, which tell the experienced blower whether to take measures to raise or lower the temperature or to "stand pat." The chief indication is the smoke which appears on the edges of the flame. The earlier the smoke appears and the more there is of it, the hotter the charge will tend to become and vice versa. The proper amount of smoke which cannot be described in words, is soon learned in practice. Within three or four minutes from the beginning of the blow one may tell if the heat will require to be warmed or cooled, if either.

Assuming that the composition (as usually understood) is correct, the quality and fitness of the steel for its intended purpose depends then largely on the temperature of the blow. Aside from the effect of temperature on the gases, the reason or reasons why too high a casting temperature gives inferior quality to the product is not wholly known although they seem to be closely connected with the crystallization, the inter-crystalline matter, and perhaps the non-metallic matter or inclusions (sonims) contained.

The means for the control of temperature are the subject of this article. It is the writer's opinion that they have never been stated collectively before and some of them are now described for the first time. Methods for obtaining hotter metal are first considered and those to cool the metal later. Some of these procedures may be applied to a heat during blowing while most of them cannot, but may be resorted to for future blows.

The methods for raising the temperature which will be considered in detail are:

1. Have metal of the charge hotter before it enters the vessel.
2. Have more silicon in the metal of the charge.
3. Have more manganese in the metal of the charge.
4. Make the depth of the molten metal in the vessel greater.
5. Raise the blast pressure.
6. Have smaller holes in tuyeres, if too large.
7. Add high-silicon-iron alloy.
8. Blow with vessel tipped part way.
9. Dry the air-blast.
10. Make linings and bottoms more durable.
11. In general run faster.

The first thing to be done is to ascertain the cause of too low temperature, which, however, may demand much study. Once that is found the proper cure may be selected and applied.

The first heat after lining or repairing a vessel is likely to lack the proper temperature unless means are employed to prevent it. The easiest way, provided vessel and ladle are well dried and heated red hot, is to have an additional half per cent of silicon in the crude iron of the charge.

1. *Have Charge Hotter Before It Enters the Vessel*—This is the obvious cure but it cannot, of course, be applied to a heat which is found to be blowing too cold. For steady work it is naturally the thing to be done as it has been well said that coke is cheaper than silicon. When the iron is melted in a cupola more fuel (coke) per ton must be charged therein per ton of iron in order to have the molten iron hotter. For instance, if, with a given rate of running, 10 pounds of iron have been melted with one pound of coke and the metal comes too cold, increasing coke to one-eighth of the weight of the iron will give distinctly hotter metal.

When, however, direct iron is blown, which is usually passed through a mixer, the initial temperature of the metal of the charge is less under control even though the mixer be "active," that is, designed for substantial quantities of fuel to be burned therein like an over-sized open hearth furnace. With a mixer, the practice should be laid out so as to have blows sufficiently hot without dependence on surplus heat in the iron of the charge.

2. *Have More Silicon in the Charge*—This is the usual well known expedient. The efficacy of silicon in this respect lies in its great calorific power (1 kilogram burnt by oxygen giving 7,595 calories), and also in the fact that the product of its combustion, SiO_2, is not gaseous and therefore, remains with all its heat of generation within the vessel, while gases which escape from the vessel carry off heat. The percentage of silicon required varies in a general way from about one per cent, in iron to be made with continuous running into ingots in a 15-ton vessel, to 2 per cent in iron to be made into castings (which require hotter steel) in a 3-ton vessel. These percentages may, of course, be changed somewhat by the other controlling causes considered hereafter. The percentages of silicon mentioned are for the charge actually entering the vessel. If steel scrap forms a part of the cupola charge and so dilutes the silicon, the pig iron must contain proportionately more silicon. The larger the vessel, generally speaking, the lower may be the percentage of silicon in the crude iron because of the smaller radiating surface per unit of capacity. In summer when the air contains more moisture than in winter, higher silicon (say 0.2 per cent) is usually needed to make up for the cooling effect of that moisture in the blast. More silicon in the metal requires more air blown in per pound of charge.

In this article the author, who is one of the foremost authorities on the Bessemer process, describes difficulties which occur regularly in making Bessemer steel. He then explains how these difficulties can be either avoided or afterwards adjusted. The observations described in this article have never before been collectively written.

3. *Have More Manganese in the Charge*—Manganese, unless, extremely high (say over 3 per cent), is usually entirely oxidized during the blow. Though it has not near the calorific power of silicon (1,653 calories as compared with 7,595 for silicon) it acts as a heat-giving element and may be used to give higher vessel temperatures. The calorific power of manganese does not, however, seem to account wholly for its charge-heating power, which is considerable. That calorific power is but little greater than that of iron of which one kilogram gives 1,612 calories when burned to magnetic oxide (Fe_3O_4). Some iron is always burned during the blow and the manganese merely replaces a part of that as shown by the fact that the presence of manganese in the moderate proportions herein mentioned does not increase the percentage of loss of the whole charge. In heat-giving effect in the blow, 4 or 5 pounds of manganese is equivalent to about one pound of silicon.

No increase in volume of air blast per pound of charge is required by increase of manganese. The reason for this fact, as well as that mentioned above, namely that the waste is not increased by higher manganese in that charge, is that the manganese protects from oxidation an equivalent of iron which would otherwise be burnt and which, if burnt, would require as much oxygen (air), as the manganese which protects it. The oxidized manganese replaces an equivalent of iron in the slag. Silicate of manganese is formed which is easily fusible.

Manganese must, however, if used, be added in proper proportion to avoid certain slag troubles. If more than 0.75 per cent and less than 1.25 per cent is present the slag is likely to be thrown out of the vessel. With low manganese (say 0.2 or 0.3 per cent) the slag is likely to be partly liquid and partly solid so that it collects in balls to some extent during blowing, and sometimes gathers in "kidneys" on the sides of the vessel which accretions require to be cut away with hammer and wedge each week-end. With higher manganese (0.75 to 1.25 per cent), the slag is fluid but very thick and sometimes it forms leathery sheets which impede the blast momentarily only to be blown out of the vessel's nose the next instant by the increased pressure of the pent-up air of the blast. This may occur repeatedly until most of the slag, with considerable of the iron, is thrown out, the whole operation being very sloppy and the loss or waste of iron unduly high. With still higher manganese, say 1.25 to 1.50 per cent the slag will be so fluid that it gives no trouble of that sort. The extremely fusible silicate of manganese formed accounts for these effects on the slag.

With 2.2 per cent of manganese and 0.7 per cent of silicon in the metal, heats have been blown with less than 5 cubic feet of air per pound of charge, which is unusually low. A charge in a 3-ton converter may blow hot enough with one per cent of silicon and 1.75 per cent of manganese while with low manganese nearly 2 per cent of silicon would be required.

Increased manganese generally causes increased smoke in the flame issuing from the vessel. This must be kept in mind in judging whether the temperature promises to be right or not.

4. *Make the Depth of Molten Metal in the Vessel Greater*—This procedure is, of course, predicated on the depth being too small in which case more of the oxygen of the air blown in will escape unburnt than should do so, and consequently the quantity of air entering the vessel will be unduly great. The unused excess carries off heat, escaping as it does at the vessel temperature, and thus cools the vessel interior and thereby the charge. A 3-ton vessel in which the

depth of metal was 11 inches gave steel too cold for small castings even when the silicon was 2.2 per cent. It was lined up thicker, so that the well was narrower and the charge was 14½ inches deep, with the result that the metal blew hot enough with only 1.75 per cent of silicon. The proper depth of the metal does not vary proportionately with the size of the charge as 16 inches has been found suitable for an 18-ton vesel. The depth should bear a proper relation to the size of the tuyere holes and the blast pressure as noted below, the correct depth being that which will cause practically all the oxygen in the air of the blast to be consumed.

5. *Raise the Blast Pressure*—This, of course, increases the volume of air per minute entering the vessel, and calls for increased speed of the blowing engine. It tends to shorten the time of blowing which lessens the loss of heat by radiation and otherwise. It thereby tends to increase the temperature of the blow. If, however, low temperature has resulted from insufficient depth of bath, raising the blast pressure will be a cooling rather than a heating variation. The case requires correct diagnosis before raising the blast pressure should be tried, or it may have the opposite effect of that intended.

6. *Have Smaller Holes in Tuyeres*—This variation, of course, implies that the holes in use are too large. In that case, making the jets of air smaller by the employment of smaller holes gives the oxygen of the air blast more chance to be completely consumed. It is a means of correcting the low temperature resulting from too shallow a bath. Thus ½-inch holes were found to be too large in a 3-ton vessel and were replaced by ⅜-inch holes, which caused the heat to blow hotter. The size of the holes should bear some relation to the depth of the bath. Half inch holes are sometimes used when the depth of bath is about 16 inches though even then a smaller diameter of tuyere-holes might give better satisfaction by a better control of the temperature.

7. *Add High Silicon-Iron Alloy*—This practice is of course merely adding more fuel, the combustion of which adds heat and so raises the temperature. If the silicon alloy or ferro-silicon is added cold, as is usually the case, the percentage of silicon in it should be over 14 per cent as the silicon by its combustion has to furnish heat for both melting and raising to the bath temperature the whole quantity added, before any heat is available for raising the temperature of the charge. Thus the thermal effect of adding 100 pounds of 14 per cent ferro-silicon to a 10,000 pounds converter charge is as follows:

$100 \times 400 = 40{,}000$ cals. to melt addition.

$14 \times 7595 = 106{,}330$ cals. from combustion of silicon.

Surplus heat $= 66{,}330$ cals.

Surplus heat per pound of charge 6.6 calories, which will raise charge temperature about 30 degrees C. 400 is approximately the number of calories to melt and raise a pound of cold iron to the bath temperature. 7595 is the number of calories from burning one pound of silicon by oxygen. 33 degrees C. is a perceptible and important amount. In fact addition of less than 100 pounds (50 pounds) are common to a 10,000 pound charge. The additions, of ferro-silicon to a charge, while blowing, is chiefly a procedure followed in making steel for castings, for which extremely hot steel may be required, particularly if the castings to be made are small or thin. It is one of the methods which may be followed with a heat while it is blowing. The individual pieces of silicon alloy should be small, not over 5 pounds weight each, so that they may be quickly melted and oxidized.

8. *Blow With the Vessel Tipped Part Way*—Doing this brings some of the tuyere holes above the molten charge and the blast from some of the others blows through the metal where it is shallow. There is therefore an excess of oxygen above the bath which burns some of the carbonic oxide gas (CO, which is the combustible gas given off during the second period) to carbonic acid (CO_2) and also burns some of the iron to oxide, both of which actions generate additional heat within the vessel and raise the charge temperature. This may be continued during the latter half of the blow. Side-blowing wastes more iron than normal blowing and the practice should be avoided as much as possible. Its good point is, that it may be applied to any single heat during blowing, and when it is too late to employ any other means, except perhaps the addition of ferro-silicon which, because of the high cost of the alloy, is not ordinarily used in making ingot steel. Hence, side-blowing is rarely used for any but ingot steel. It is the second method which may be employed with a heat while blowing is going on.

9. *Dry the Blast*—This plan proposed by Gayley, has been tried as an experiment but was given up because (it was announced) the bath temperature was raised in a harmful and uncontrollable way. At that time, steel scrap was worth more than pig iron (about in proportion to its iron Fe content) and its use in the large proportion that was indicated as being needed, appeared to be uneconomical. It raised rather than lowered the cost of the product when the cost of drying the air of the blast was included. At present prices such an objection would not hold to the same extent, and drying the blast looks like a promising development for the future.

10. *Make Linings and Bottoms More Durable*—By accomplishing this the quantity of material melted and scorified from the lining and bottom is lessened and therefore less heat will be absorbed in melting and raising it to the bath temperature, and in heating the freshly exposed refractory material. In this matter each plant must work out its own salvation. No two have the same materials at hand, at the same cost, due to differences in freight rates. All the likely bricks, clays and ganisters within reach should be tried, and those adopted which are found to be best suited to the particular practice maintained.

11. *Run Faster*—Aside from the conditions mentioned which make for faster running, the essential feature to accomplish it is to avoid or cut out all lost time. Time between blows and time taken for changing bottoms between blows and time taken for changing bottoms should be cut short. Nothing should have to wait for the next preceding thing to do its part or the next succeeding thing to "carry on". Thus after a heat is poured from the vessel to the ladle, the next heat should be ready in its ladle and be at once poured into the vessel. This metal ladle must have received its charge from the mixer long enough beforehand, that it may be hauled to the converter and be ready for the charge to be poured in, as soon as the vessel reaches the charging position. This is easy to say but efficient administration is called to keep up this sequence of motions. For the whole works this extends from the receipts of ore to the shipment of finished goods, assuming that the field of operations at the works in question is that broad. The record is not broken by feverish haste but by cool forethought that things which might prove hindrances are avoided. It is,

of course, by lessening the time for heat losses by radiation, conduction and convection that faster running tends to give hotter steel. Some of the methods hereinbefore described for having hotter heats make for faster running and therefore for larger output particularly numbers 1, 4, 5 and 10, as may be recognized on reflection. Thus, hotter metal (1) requires less silicon and less silicon requires less air and shorter time of blowing which, of course, permits more blows to the turn and therefore greater output. Similarly, the greater depth metal (4) lessens the silicon required with the same result. Raising the blast pressure (5) and more durable linings and bottoms (10) also by saving time increase output.

The use of greater depth of bath, smaller tuyere holes, lower silicon and 1.75 per cent manganese in the charge collectively effected a decrease in the volume of air blast required from 7½ cubic feet per pound of charge to less than 6 cubic feet and shortened the time of blowing from 15 to 12 minutes.

Next we will consider the means which may be employed when heats are wanted to be cooler. Some of these are naturally in a general way the opposite courses to those laid down for enhancing the charge temperature. Such are numbers 1, 2, 3, 4, 5, 6, 10 and 11. Of these only the first three should ordinarily be considered. No. 2, diminishing the percentage of silicon in the metal, is the principal one resorted to before the charge reaches the vessel. Sometimes, however, less coke for melting or less manganese in the metal may be adopted, if the practice has been to use them too freely. Some methods are, however, peculiar for avoiding too hot heats. Those demanding consideration here are:

1. Have less silicon in the charge.
2. Add cold iron or steel scrap or washed metal.
3. Blow steam into the blast.

1. *Decrease Silicon*—This decreases fuel and therefore the heat supply. The temperature of the charge during the blow is not decreased in proportion as the silicon in the metal is diminished, because (1), the volume of air blast required per pound of charge is lessened and so the quantity of heat carried off by the escaping nitrogen is less, (2) the time of blowing is shortened and the loss of heat by conduction and radiation proportionately diminished. Unless these are allowed for, the first diminuition of silicon for the purpose of having the heats blow colder may not have in full, the desired effect.

2. *Add Cold Iron*—This cold iron may be in the form of steel scrap or pig iron (not high in silicon preferably) or washed metal (which is always practically free from silicon). The cooling effect of such additions is obvious as they absorb heat in being melted and raised to the bath temperature. The additions are made to the charge in the vessel while it is being blown, and as soon as indications have appeared that the temperature threatens to become too high. The addition of 100 pounds of soft steel scrap to a 10,000 pounds charge cools it about 16 degrees C.

$$\frac{100 \times 400 \times 1600}{10{,}000 \times 400} = 16 \text{ degrees}$$

1600 degrees C. is assumed as the temperature of the blown iron. 400 is approximately the number of calories to bring one pound of cold iron up to bath temperature.

An experienced man can tell within a hundred pounds how much scrap a 5-ton blow should have added, which means that he can control the temperature of the metal within 16 degrees C., a very important fact.

The usual practice in making ingot steel is to have the conditions as to the initial temperature, percentage of silicon, etc., such that the tendency is for the heats to blow too hot, and then to add scrap to cool them to the proper degree. This puts the scrap added into ingots practically without cost. When castings are being made the desired temperature is aimed at initially and additions to heat or cool are made as developments indicate them to be needed.

3. *Blow Steam Into the Air-Blast*—Steam is water and water is the universal cooler so it is a sure cure for a heat that is blowing too hot. Whether or not it is detrimental to the quality of the steel is still an open question. The steam (water) is decomposed in part at least by the molten iron which combines with its oxygen and sets free its hydrogen. This latter is not desired in steel because of its part in the formation of gas holes and the oxide of iron formed is so much waste. Still steam is employed in blowing ingot steel, though not for castings, as far as known to the writer.

As in the case of heats blowing too cold, those blowing too hot should be correctly diagnosed before treatment is prescribed.

MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The 1921 spring meeting of the American Society of Mechanical Engineers is to be held in Chicago, May 23 to 26, at the Congress Hotel.

Well developed programs will be presented by the professional divisions of the society devoted to forest products, fuels, machine shop, management, material handling, power, railroad, and a specially important session will be devoted to training for industries. The Chicago committee, jointly with the Western Society of Engineers, is preparing a session on "Chicago as the Rail-Water Gateway."

Visits to a great number of points of engineering interest in Chicago will be arranged. Special attention is being given to the co-relation of plant visits with the technical sessions.

En route to the meeting, the society, jointly with the Society of Automotive Engineers, will stop at McCook Field on Saturday, May 21, for an inspection of the facilities of the field.

On May 27-28, the Friday and Saturday following the meeting, a joint excursion with the Army Ordnance Association will proceed to Rock Island arsenal, where the Ordnance Division will present papers and enjoy an inspection of the plant. Saturday will be devoted to a handicap golf tournament on the Rock Island links.

ORDNANCE DIVISION.

Preparedness is largely a problem for the egnineer. That this matter should have constant attention on the part of the mechanical engineer, as the engineer of the industry, is well understood.

The opening activity of the Ordnance Division of the A.S.M.E. will consist of an excursion to Rock Island arsenal with the Army Ordnance Association on May 27-28, the two days following the A.S.M.E. spring meeting in Chicago. This excursion is limited to members of the two organizations who are citizens of the United States not engaged in the manufacture of munitions for foreign governments.

Mechanical Handling of Steel Mill Material

A General Description of Modern Methods Employed by Steel Mills in Handling Materials—Economy and Increased Tonnage Are Obtained.

By C. F. POPPLETON.

THE modern steel industry has advanced so rapidly even our fathers would hardly recognize a plant of today. Mechanical equipment that was looked upon as "faddy" even as recently as 15 years ago, is now an absolute necessity, that is if the plant is able to compete for business in the open market.

The purpose of this article is to show briefly the main lines of demarkation, between the practice which was followed by the pioneers of the industry in the United States and the practice that is necessary for the economic operation of a present day steel plant.

The logical place to start is at the stock yard. Within quite recent years the necessary materials, ore, coke and limestone were unloaded by hand from the railroad cars (these cars were run of service cars and not specially designed cars for steel works service as at present) and piled in a more or less haphazard manner in the space allotted for stock. From these piles the stock was loaded by hand into wheel-barrows and wheeled to the hoist at the foot of of the furnace stack. The old-fashioned hoist consisted of a vertical tower, usually of channels and angle framework which formed at the same time guides and support for the cages. The stock was then raised by means of cages to the top of the furnace.

Charging a Blast Furnace.

For those of our readers who are not familiar with the method of charging a blast furnace it will be well to describe the operation. The top rigging of the furnace consists of two bells, one much larger than the other. These bells are cone shaped castings, and are suspended one below the other; the large bell being underneath. The vertical shaft supporting the top or smaller bell is hollow and the larger bell support is operated inside of it. The bells are arranged with the points of the cones upward, and they each seat themselves on a cast iron or steel ring, in such a manner that they are practically gas tight when closed. The usual method in the hand filled top rig under description, is for the furnace top crew to wheel the stock from the cage of the hoist and dump the limestone ore or coke on to the top bell. When the predetermined quantity of stock is dumped, the top bell is lowered and deposits its burden on to the bottom bell. After the requisite number of charges have been deposited on the bottom bell, the top bell is closed tight, and the bottom bell is in turn dumped, thus feeding the charge into the top of the furnace proper. This alternating charging of the top and bottom bell mixes the ore, coke and limestone. The bells are usually operated by means of either steam or hydraulic cylinders. At the outer end of the levers balanced weights are arranged in such a manner that they keep both bells closed.

As will be seen from the description, the method of hand filling necessitated the presence of a crew on the furnace top. This was not only costly labor, but exposed the men to the very serious danger of being "gassed".

The next improvement, and it occurred after quite a number of years was at the foot of the furnace, and consisted in the use of specially designed bottom dump cars for the stock, and elevated trestles over bins for the ore, coke and limestone.

The next step was very radical, and consisted of an inclined skip hoist with a specially designed bucket, which was automatically dumped at the top of its travel. This dispensed with the top filling crew and the greater portion of the bottom wheelers and fillers. Many engineers were contributors to this result, but perhaps the greatest individual credit belongs to Mr. Julian Kennedy, of Pittsburgh, Pa.

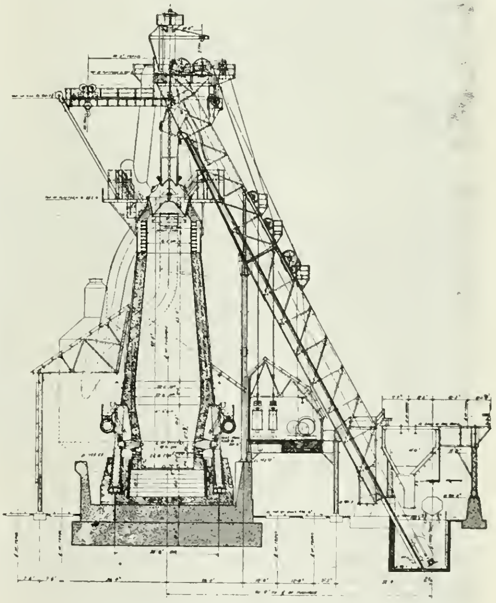


Fig. 1—Cross section of modern blast furnace.

Fig. 1 shows a typical cross section of a modern blast furnace. This shows wherein lies the vast difference between the obsolete vertical hoist and the inclined skip hoist with its attendant manifold advantages. It will be seen that it is easily possible, not only to clear the furnace columns, but to spot the ladle and ladle car and if necessary one or even two standard gauge tracks under the skip incline, and at the same time allow sufficient head room for the highest standard cars or locomotives. The skips may be sunk in a pit and the ore, limestone or coke cars, located on a suitable trestle can be unloaded by gravity. The hoisting engine and its house can be profitably arranged to form part of the trestle structure, making the loading of the skips, and the proportioning of the burden of the furnace not only easy of accomplishment but more accurate than in the previous method.

It is wise to arrange the discharge from the bottom dump cars onto an inclined platform, which in turn leads into the chutes directly over the furnace skips. These final chutes should be in the form of bins with their openings directly over and close to the skips. These bins, by means of the requisite arrangement of gates may be made capable of measuring the charges delivered to the skips. The levers controlling these gates can be arranged in the hoisting engine house, so that the engine man has complete control of the charges and the raising and lowering of the skips to the furnace top. When the skips are at the top of their travel a hook mounted on a sheave engages with a suitable bar on the underside of the device which arrests the upward travel of the front end, the rear end of the skip bucket being still propelled in the upward direction by the hoisting cables turn the bucket to the required angle to discharge the contents, this takes place when the bucket is directly over the small bell already described in the description of the method of filling the furnace.

There is no necessity during the ordinary run of operations of more than one man being stationed on the furnace top. His duties are to operate the levers controlling the large and small bells alternately.

These advances seemed to be the turning point as they were rapidly followed by the traveling ore bridge, which enabled stock to be economically handled from widely separated parts of the stockyard, and rendered the expensive stock bins to a great extent unnecessary. They also enabled another great invention to come into use in the shape of a car dumper. This machine takes a fully loaded car of stock off the tracks and hoists it up clear of all obstructions then turns it upside down and dumps the contents in a pile where they can be reached in turn by the traveling ore bridge and fed to the skip buckets.

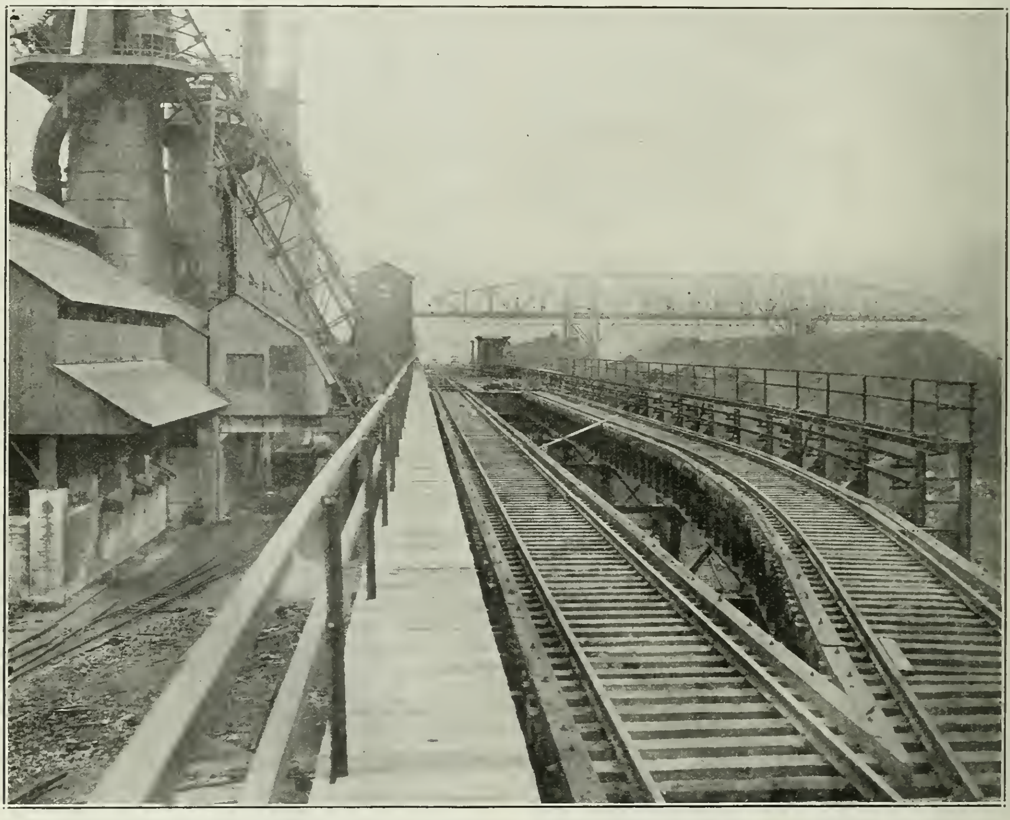


Fig. 2—Ore yard, ore bridge and high line at the Midland Plant of the Pittsburgh Crucible Steel Company.

One of the main reasons why these improvements at the blast furnace end of the steel plant were so long coming about was the fact that they nearly doubled the capital outlay necessary to construct a furnace of a given size. This fact had the natural tendency to increase the size of the furnaces afterward constructed, as it was found that the same ore bridge and car dumping equipment necessary to serve a 350-ton furnace would suffice for a 500-ton or even larger unit.

Fig. 2 shows a view of a modern ore yard equipped with an ore bridge and high line. Note how the material is entirely mechanically handled. This view was taken at the Midland plant of the Pittsburgh Crucible Steel Company.

The next step was the moveable car dumper. The author prefers this type to the stationary type. This machine moves on trucks traversing the entire length of the storage yard and dumps the ore over a restraining wall. It is admirably suited for this purpose as it is possible to move the machine opposite the proper portion of the storage yard, thus making the required distribution directly. Any size car can be handled at speeds up to 30 cars an hour. The inclined approach and discharge tracks are attached to the machine and travel with it.

Before leaving the blast furnace end of the industry it may be well to consider other improvements that have been made although they do not enter into the subject matter of this article except incidentally.

In the pioneer days the molten iron was run into sows and pigs in open sand on the cast house floor. This was a very wasteful method and required a veritable army of iron lifters. The resulting product (pig iron) was allowed to become cold and then remelted in the open hearth furnace. A pig casting machine was then designed. This machine consists of a series of cast iron molds mounted on endless chains, and so arranged that the hot metal from the blast furnace is first run into a ladle and from thence poured slowly into the molds, which are kept traveling on their chain belt. The belts are 130 to 140 feet long in two strands and so arranged that they pass over sprockets at both ends, allowing molds to return empty and upside down to the pouring place. The discharge end is arranged over a submerged track and the pigs are discharged by gravity into a waiting car, thus saving all man-handling of the pigs.

Leaving the blast furnace end of a typical plant the next stage is the duplexing plant. This consists of a hot metal mixer and a Bessemer converter. The material is all mechanically handled from the blast furnace to this plant. The hot metal is tapped out of the iron notch of the furnace into a ladle similar to that shown in Fig. 3, which is in turn mounted on a ladle car also shown in the figure. This car is of standard gauge, and is propelled from the blast furnace to the duplexing plant by means of either electricity or steam, usually steam. As will be seen by looking at Fig. 4, the ladle is provided with trunnions, which rest in lugs on the ladle car, when the locomotive has placed the ladle with its car under the crane, the hooks of the crane engage in the ladle trunnions and the hot metal is poured into the mixer. The function of the mixers are to mix the predetermined, and different chemical analyses of molten irons, sufficient of the different constituents being added in the ladle at this stage. As will be seen the mixer is revolvable, and after the mixing action has progressed sufficiently the mixer is tilted backward and an amount is poured into another and smaller ladle which with its car is mounted on the converter platform. This ladle of mixed iron is moved in front of the converter vessel, which is tilted to receive the mixed charge. The ladle is tilted by means of a jib crane and the charge poured into the converter which is the ntilted into the upright or blowing position, the blast is then turned on. blowing position, the blast si then turned on. This is kept on for the requisite time, usually 15 to 20 minutes, and the converter is then moved over the full arc of its travel and discharges the metal into a third ladle. This ladle and car is on ground level, and from this point it is conveyed by another works locomotive to the open hearth furnaces. The function of the Bessemer converter is to blow all the carbon out of the mixture. At the open hearth sufficient carbon, silicon, manganese, and other ingredients are added to make the resultant mixture of the desired chemical analysis.

As described the bulk of the metal is charged hot from the duplex plant into the open hearth, but a small amount of cold scrap is always used. This cold scrap is handled by means of a charging machine, which machines are of two main types viz. the low type machine and the high type. There is little to choose between the two types and considerations of headroom, etc., are usually the deciding factors in making the choice.

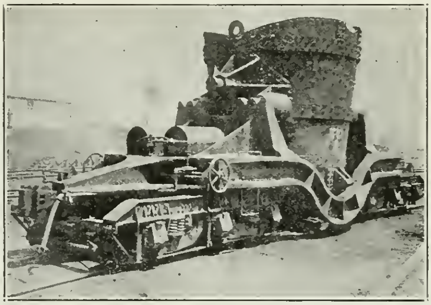


Fig. 3—75-ton hot metal car, Penna. Engineering Works.

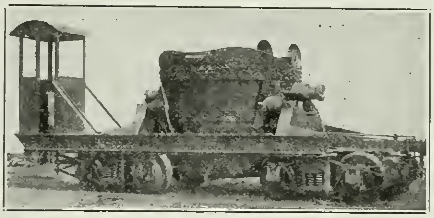


Fig. 4—65-ton metal transfer car, Penna. Engineering Works.

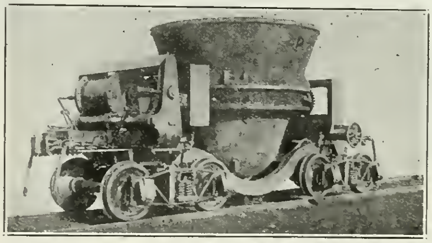


Fig. 5—320 cu. ft. cinder car, Penna. Engineering Works.

In charging cold scrap a long plunger called a peal is used. This has its end shaped to engage in the V shaped slot which is cast on the end of the charging box. These charging boxes used to be almost exclusively made of steel plate, but the preference today is for cast steel boxes.

They are doubtless far superior in rigidity and heat endurance which means a longer life, the width and height are 1.10½ inches and 1.6 inches, respectively, while the usual lengths are 6, 7 and 8 feet. Boxes of 4 and 5 feet length are often used on smaller furnaces. These boxes are oblong in shape with the bottom curved to a fair size radius, and are pushed into the furnace by means of the charging machine, which propels the peal over the molten steel on the hearth. When the peal is at full outward stroke the box is turned upside down and discharges its scrap contents on to the hearth. The peal is then revolved another half revolution and withdrawn and the operation is repeated. This work used to be accomplished by hand, and of course nothing like the tonnage now obtained was possible, nor was the uniformity of product now obtained possible.

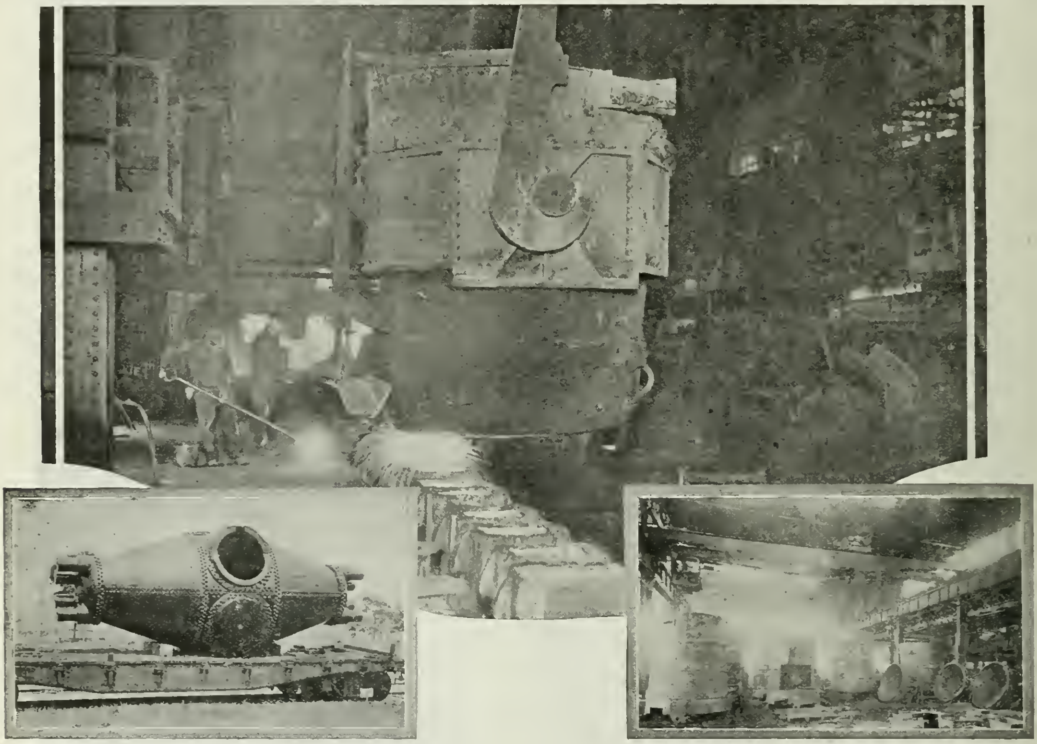


Fig. 6—Pouring a heat with equipment built by the Treadwell Construction Company.

Of a total charge of 2060 pounds of metal in an average (50 ton) furnace a fair proportion would be 1120 pounds of hot metal and 95 pounds of cold pig iron, the balance being made up of bloom crops, plate scrap, ingot butts, rail scrap, turnings, and other light scrap. These latter ingredients must not exceed 140 pounds in the quantity given above because on account of their light weight in comparison with their exposed surface they would oxidize and burn up instead of becoming molten. Records of 3 hours and 40 minutes to melt a total charge of 32,000 pounds of steel from cold metal are not uncommon.

When the heat is ready to pour a ladle such as is shown in Fig. 6 is suspended on the hooks of the ladle crane. The weight of the steel thus tapped is predetermined, and sufficient ingot molds mounted on stools, which are in turn mounted on ingot mold cars, are prepared to receive the melt. These ingot molds, and the ingot mold cars are shown in Fig. 7. These ingot mold cars have M. C. B. couplings and fittings and are run on standard gauge tracks. A second steam locomotive is attached to a train of these cars, usually three to four cars each having four ingots of about 7 tons weight as a load. The locomtive places this crane where it can be reached by the stripper crane and then returns either to take a ladle of hot metal from the duplexing plant to the open hearth or to bring another train of ingot cars to the stripper crane.

The stripper crane is then reached. This is a specially designed overhead electrical traveling crane, having hooks to engage in the hooks of the ingot mold and a plunger which is operated downward at the same time as the hooks are lifting, the plunger enters the hole through which the hot metal was poured into the mold and forces the ingot downward while at the same time the crane by means of its hooks is stripping the mold from the ingot. Of course a certain amount of time has to elapse between pouring and stripping to allow the ingots to cool and solidify to permit this operation. The stripped ingots are allowed to remain on their stools and their cars and are moved by the locomotive under the soaking pit crane, This crane is also an overhead electric traveling crane and is equipped with hooks resembling exaggerated ice tongs. These tongs engage the top of the stripped ingot and place them in the soaking pit.

The function of the blooming mill is to reduce the ingots to blooms. The ingots usually have a cross section of 22 by 22 inches at the small end and 27 by 27 inches at the larger end, this taper being necessary to allow for stripping the ingot molds. They vary from 5′ 6″ to 6′ 6″ in ordinary cases, and they are reduced on the blooming mill to blooms 8 by 8″ in section. At this size the blooms are sheared into workable lengths and are passed on to the billet, bar or shape mill.

A typical blooming mill manipulator is shown in Fig. 8. This manipulator was built by the McIntosh-Hemphill Company of Pittsburgh, Pa., for the Mark Manufacturing Company of Chicago, Ill.

This manipulator is so designed that it has no racks or mechanism of any kind underneath the tables, everything being so laid out that it comes outside of the tables at all times. The tilting feature is new, inasmuch as the whole moving side guard, on the tilting side is raised up and has hanging on it several tilting fingers which catch the piece and turn it over. This is accomplished by means of a tilting cylinder placed alongside the table beams. The manipulator is self-contained and has no connection with the table whatever except on the pusher side where the ends of the pusher rods are carried on the table beam.

A shear approach table is usually of standard design, motor driven and adapted to fit into a 10x10 vertical geared bloom shear. The shear delivery table is so designed that the tilting and stationary sections may be moved away from the shear to allow the crop ends and small slabs to drop into a chute and then into the scrap box. This arrangement is necessary to avoid the delay which would be caused if this unavoidable by-product had to be man-handled.

After the final pass through the blooming mill the bloom or billet is conveyed to the bloom shear. The function of the bloom shear is to cut the hot bloom into such pre-determined lengths as are necessary for the particular order being dealt with. The necessity of this becomes apparent when it is remembered that an ingot which has a section of 22 x 22 inches at the small end and 27 x 27 inches at the large end and a length of 5 feet 6 inches will roll out to an 8 x 8 inch bloom over 60 feet long.

The system of handling the hot ingots, blooms, slabs, bars, shapes or plates has been standardized and in nearly all cases, this being accomplished by means of rolling mill tables. These consist essentially of side frames which support the bearings of the live rollers. These rollers are of varying diameters to suit the work but are usually of the same diameter for the same table to save repetition of patterns.

Fig. 9 shows a typical plate mill, the length of which is so great that the mill proper appears away in the background. This mill is a United Engineering & Foundry Co.'s installation and the illustration was chosen because it shows clearly the tables in operation, and serves to illustrate the method of mechanically handling all rolled material, as the same principle is employed whether the product is bars, shapes or other semi-finished products of the ingots. This mill is of the 3 high or Lauth type and has two rolls, the top and bottom, about 32 inches in diameter and the center one much smaller. The large rolls are stiff enough to preserve their alignment, the loss of which would mean plates thicker in the center than on the edges. The smaller center roll is supported while at work by one or the other top or bottom rolls and does not need to be so large.

This illustration also shows very clearly the arrangement of the castor beds later described. Until comparatively recent years all sides of the plates were squared by means of cross-cut shears, rotary side trimming shears being only used for wide skelp and universal mill plates. In order to make the rotary side trimming shears a valuable adjunct to a modern plate mill layout recent improvements have been made. One shear housing is stationary, while the other housing is arranged to travel along the bed plate, so that plates of varying widths can readily be sheared. The movable housing is propelled by a motor through gearing and a lead screw and an indicator is provided so that changes in width of plate can be made so quickly that each successive plate can be sheared to a different width. The adjustment of the top knife was at first accomplished by means of a hand wheel, this is now performed by a motor, and all adjustments are quickly and easily made. These rotary shears are made in two sizes, one having a capacity of ½-inch cold plate, and the other 1-inch cold plate. Either size can be made to take care of any width from 30 inches up.

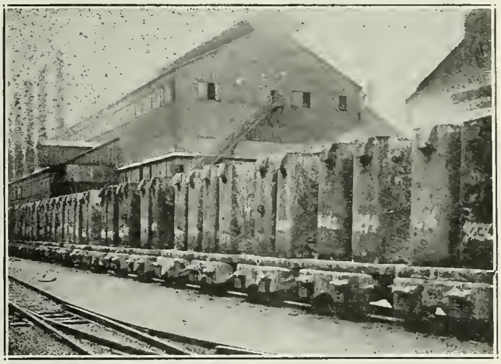


Fig. 7—Ingot moulds and ingot mould cars. These cars are equipped with Hyatt Roller Bearings.

For trimming wide skelp and all rectangular plates these shears are without a question, the best equipment yet produced, and labor costs will soon make them an absolute necessity in a mill.

The tables in all modern mills are driven by electric motors, which are preferably variable speed, reversing type. The rollers are cast steel cylinders of the requisite length, and are supported in bearings at both ends. The bearings must be very amply proportioned as the service is very severe, and there is a tendency in up-to-date mills to use roller bearings.

Considerations of space, particularly in the lengthwise dimension of the mill site render it necessary to resort to transfer tables to pass the product from one mill to another.

In rail mills these transfers are usually constructed of chains. The rails being run out onto the hot bed after the final pass. These transfers are electrically driven and are used to take the rails to the hot saws, straightening presses, drill presses, etc.

In many of the other mills which are in common use in the steel industry, it is necessary to transfer the product from one mill to another before the rolling operation is concluded. For this purpose many different types of transfers are made use of, all having the same main object, the reduction of manual labor. One very efficient transfer is a standard, electrically driven rolling mill table, this is mounted with its motors on rails running at right angles to the mills and is propelled from one mill to the other. The tables are reversing, and by means of a duplicate table on the other side of the second mill the piece is returned through the second reduction pass, this is repeated as many times as are necessary and the piece after its last pass on that particular mill is again pointed in the right direction viz, from the blast furnace and open hearth toward the shipping point.

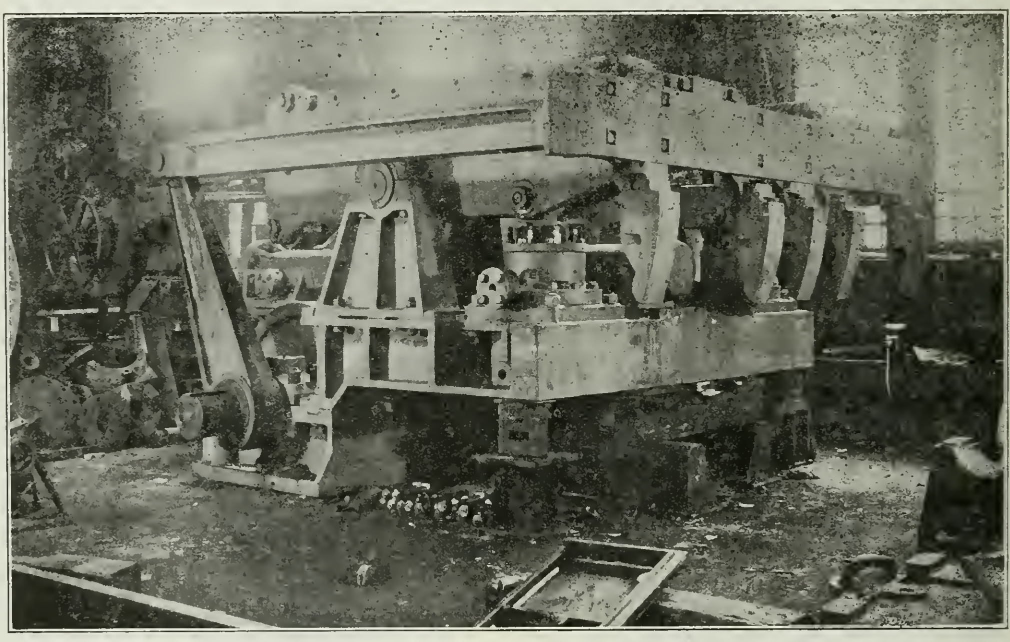


Fig. 8—Showing tilting side of McIntosh-Hemphill Company Manipulator.

In plate mills a very ingenious method of transfer is employed in the form of castor beds. These consist of heavy cast iron circular bases having a vertical shaft on which is mounted the "castor" this being exactly the same in construction as the familiar furniture castor. These castors are movable and the bases are made heavy enough that they will "stay put."

Yard Equipment.

This is a very important part of the successful mechanical handling of materials in any plant.

This equipment must be fully adequate to handle all materials, ore, coke, limestone, refractories, fluxes, oils and other supplies, fuels, other than coke and the miscellaneous other materials inward, but must also be fully adequate to handle the finished product, and wastes outward, besides being amply prepared for the necessary shifting of materials, supplies and product in the process of manufacture.

This equipment consists of steam and electric locomotives, locomotive cranes, weigh bridges, works rolling stock as apart from Railway Company's cars, and last, but not by any means least, the track system.

In many of the earlier steel works the system of trackage received all too scant attention. In the author's opinion this is one of the most vital single parts of steel works design. This will be apparent when the fact is taken into consideration, that even where the trackage and transportation facilities (that is within the works) have been given the most careful consideration and study, every 5 tons of finished product that is shipped necessitates the moving of either a full or empty car to a certain distance.

At all points where materials arrive, ladders should be provided, the car space on these ladders of course depending on the extent of the material to be handled, but there should be not less than four lines of parallel tracks. Track curves should be as sharp as possible, as long as the danger of derailment is avoided. For standard gage tracks a curve of 339′ .0″ radius, and for 3′ .0″ gage a radius of 50′ .0″ are practicable and have been found satisfactory. In extreme cases much shorter radii have been used, but are not to be recommended if it is in any way possible to avoid them. For the curve (339′ .0″) on standard gage track a No. 6 standard frog will be required. As far as possible all frogs and switch points should be of the same number, length and planning. Alteration of the curve radius should be made beyond the heel of the frog. Ground throw switches should be used, as they are less liable to be the cause of injury to men walking on the tracks particularly at night.

Locomotives.

In the usual layout of a modern steel plant the steam locomotive has been found preferable, this mainly on account of the absence of overhead electric cables. On the other hand, for by-product coke ovens, which are very often run in conjunction with a steel plant, the electric locomotive is perhaps to be preferred.

Fig. 10 shows a typical steel works, steam, locomotive. This was built by the H. K. Porter Company of Pittsburgh, Pa. The outstanding feature of this, as must be the case in all steam locomotives intended for steel works service, is its ability to run with safety around curves of the minimum radius, and its comparatively heavy drawbar pull.

In a modern steel plant all the yard equipment should be under the direct charge of one official, a good title for whom is Superintendent of Labor. His duties should cover the handling of all materials of every nature in the plant.

From the above it will be seen that the duties of this official play a very prominent part in the elimination of manual labor, and he must make an intensive study of the mechanical handling of all material that comes under his charge. The most economical division of the car shifting operations is to use three steam locomotives for the three main divisions of the work. The first taking hot metal from the blast furnace to the duplex plant or to the open hearth. The second taking hot metal from the duplex plant to the open hearth charging side and afterwards moving the ingot cars under the soaking pit crane. The third locomotive should be to handle the finished product up to the point of delivery to the railroad company. This will naturally include all car shifts incidental to this service and also the shipment of the wastes.

Locomotive cranes are admirably adapted for handling ore in buckets and other materials at the stockyard, and for transporting skulls, ladle bottoms by means of magnets, from the place of origin to the skull cracker, and transporting the broken skulls, etc. from the skull cracker to the place of disposal and other like service. They can also be used to advantage for spotting cars where necessary in the stockyard or elsewhere throughout the plant, leaving the steam locomotives free for the regular routine services as already outlined, and without which it is impossible to operate continuously.

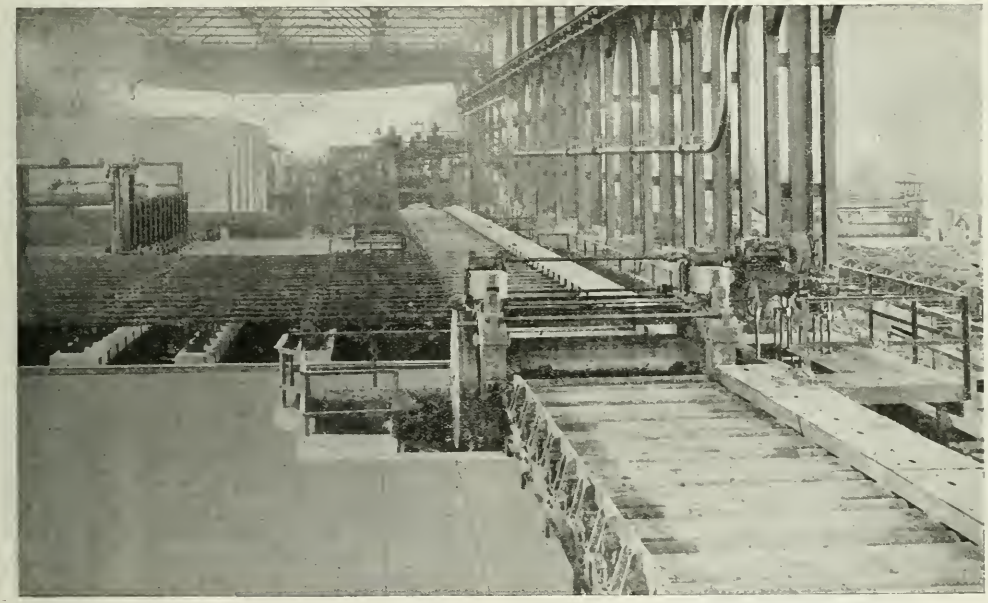


Fig. 9—A plate mill built by the United Engineering & Foundry Co., equipped with every modern improvement, Brier Hill Steel Company.

Fig. 12 shows a typical locomotive crane made by the Industrial Works of Bay City, Mich. All locomotive cranes function in exactly the same manner, so that considerations of price, delivery and freight charges are usually the factors determining the choice of makers.

In plants where there is no skull cracker building, or in those plants where there is such a building provided, the locomotive crane is often used as a skull cracker. This is easily accomplished by substituting a standard 36-inch magnet for the usual bucket. The jib of the crane has sufficient elevation to allow the ball to fall through sufficient height to crack the ordinary skull. This is a very convenient feature of an equipment of one or more locomotive cranes, as it is not always convenient to transport skulls, etc.

to the skull cracker, and in many cases the skulls or ladle bottoms can be handled at a point much nearer their place of occurrence, thus saving travel of both the skull and the broken pieces.

A skull cracker building should be an integral part of a well laid out and equipped steel plant. This building is usually located on space which has little value and is about 50 feet span by about 150 feet long and 60 feet high to the lower chord. It is equipped with an overhead electric traveling crane usually of 10 tons capacity. The skulls, ladle bottoms or other material, which it is desired to break up into charging box sizes, are brought under the crane (tracks are provided for this purpose) usually by locomotive crane. The overhead crane is equipped with a magnet usually 36 inches in diameter, this magnet being allowed to engage with a ball of about 5 tons weight. As a rule the ball is lifted to the topmost travel of the crane hook and the current shut off the magnet, the ball falls and the scrap, skull or other material is broken up, this operation is repeated until the material is reduced to charging box size.

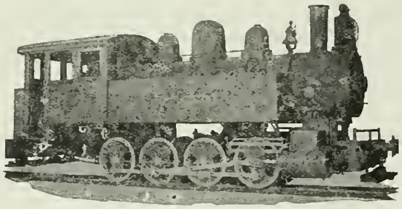


Fig. 10—H. K. Porter locomotive for steel plant use.

All the materials used in the open hearth portion of a modern steel plant should pass through a suitable stockyard. It is good practice to have this separate from the main or blast furnace stockyard. It is thus possible to keep properly classified all of the charge materials, fluxes, refractories, high-priced alloys and recarburizers. These latter in fact should be stored in separate bins to avoid loss.

This part of the plant should be laid out with special care as to handling facilities, so that manual labor shall be eliminated to the minimum. Ample track facilities should be provided for locomotive cranes, and the entire space should be covered by an overhead electric crane. The tracks should be laid out to economize space, as the ground is much more valuable for storage piles than for empty, or only occasionally used trackage. Frequent cross-overs must be provided between parallel tracks so located that cars standing for unloading at one bin may be conveniently by-passed for placing at another bin without disturbing the first car.

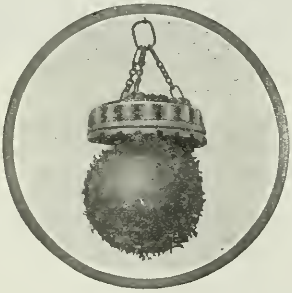


Fig. 11—Cutler Hammer magnet.

For overhead traveling cranes a capacity of 10 tons will be sufficient. If but one crane is used it should be rigged to substitute a charging box sling for the usual magnet without undue loss of time. Locomotive cranes operating lifting magnets have a small engine and generator located in the forward part of the turn-table near to the bearings of the boom.

Ladles.

Ladles play a very important part in the handling of the materials in a steel plant. They are of many sizes, from 4 or 5-pound capacity, used in the chemical laboratory to the 100-ton ladle used in conjunction with the ladle crane. Fig. 5 shows the pouring side of the open hearth cinder ladles, which are used for transporting cinder from the blast furnace to the place of disposal. These ladles are mounted on ladle cars, equipped with standard M. C. B. couplers and arranged to operate on standard gage tracks. As a general rule cinder ladles are not demountable, being seldom used apart from their cars, in which respect they differ from the hot metal ladles which are provided with trunnion, so that they may be dismounted from the cars and swung by means of their trunnions from the hooks of the various cranes. These trunnions serve a double purpose as they form pivots around which the ladles may be turned for the purpose of pouring out their contents. All ladles that may at any time be used for hot material must have a substantial lining of very refractory firebrick. Ladle lining repairs constitute a very heavy item of expense, so the greatest care is taken with the design and handling of all ladles and ladle cars.

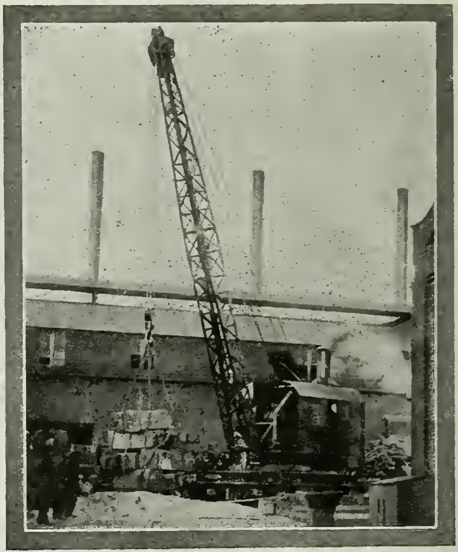


Fig. 12—"Industrial" locomotive crane at plant of Inland Steel Company.

Heat Transfer in Open Hearth Furnaces

Some Considerations Regarding the Manner in Which Heat Is Transferred From the Flame to the Bath in an Open Hearth Furnace.

By HENRY WILLIAM SELDON,
See—Seldon and Associates, Engineers, Pittsburg, Pa.

MECHANICAL Engineers' Pocket Book, Wm. Kent 1916, describes the three methods of heat transfer as follows:

Conduction, is the transfer of heat between two bodies or parts of a body which touch each other. Internal conduction takes place between the parts of one continuous body and external conduction through the surface of contact of a pair of distinct bodies.

The rate at which conduction, whether internal or external, goes on, being proportioned to the area of the section or surface through which it takes place, may be expressed in thermal units per square foot of area per hour.

Convection, or carrying of heat, means the transfer and diffusion of the heat in a fluid mass by means of the motion of the particles of that mass. Ex. (by air currents)

Radiation of heat takes place between bodies at all distances apart and follows the laws for the radiation of light. The heat rays proceed in straight lines and the intensity of the rays radiated from any one source varies inversely as the square of their distance from the source. The quantity of heat radiated by a body is also a measure of its heat absorbing power under the same circumstances. When a polished body is struck by a ray of light it absorbes part of the heat and reflects the rest. The reflecting power of a body is therefore the complement of its absorbing power, which latter is the same as its radiating power.

Flame may be defined as a mass of intensely heated gas in a state of combustion, although it is possible for flame to exist as a gas not actually in such a state.

The luminosity of flame, or the characteristic which gives its visibility, is due to the heating to incandescence of the unconsumed particles of combustible matter present in the gas. The variation in the colors of flame is due to the difference in the degree of heat communicated to these particles. The higher the temperature of these particles the whiter the flame. The length and volume of the flame will vary with the combustible elements present and the thoroughness with which the air and combustible elements are mingled and since such number will decrease with an increase in the completeness of combustion, the shorter the flame, in the absence of any outside cooling medium, the more rapid and complete the combustion. If it were possible for the combustion of any fuel to be complete and instantaneous there would be no visible flame, since both carbon dioxide and water vapor are invisible.

Visible flame, then is evidence of incomplete or non-combustion, but such evidence in the commercial furnace means simply that the combustion has not taken place with sufficient rapidity to evolve heat instantaneously.

It follows from the above that for a given amount of fuel burned, a short flame will ordinarily mean rapid and complete combustion, a longer flame delayed combustion and a very long flame imperfect or non-combustion.

It is well to distinguish between perfect and complete combustion.

Perfect combustion is the result of supplying the requisite amount of oxygen for union with all of the oxidizable constituents of the fuel and utilizing in combustion all the oxygen so supplied.

Complete combustion on the other hand results from the oxidization of all the combustible constituents of the fuel but does not of necessity imply the utilization of all of the oxygen supplied.

The speed of combustion is dependent upon the affinity of the combustible matter for oxygen and the conditions under which combustion takes place. The chief of these conditions is that of temperature. It does not of necessity follow that by bringing oxygen into the presence of a combustible substance that combustion will take place. Every combustible substance has a temperature called its ignition temperature below which it will not burn or in other words unite with oxygen.

Ignition temperatures with which we are concerned are as follows:

Ethylene	C_2H_4—1022 degrees(F)
Hydrogen	H_2 —1130
Methane	CH_4 —1202
Carbon Monoxide	CO —1210

Excess air passing through the furnace and mingling with the actual products of combustion absorbs heat from such products more readily than will the bath of the furnace, and a considerable portion of the heat so absorbed is carried off in the escaping gases. This accounts for a part at least of the increase of the exist gas temperature with an increase of excess air. Another factor is dependent upon heat transfer rates namely difference in temperature between the gases and the bath, the percentage of total heat absorbed through radiation and the percentage of total absorption through convection.

The following from the Babcock & Wilcox boiler data:

The amount of heat absorbed by any surface from a hot gas is usually expressed as a product of the difference in temperature between the gas and the absorbing surface into a factor which is commonly designated as the "transfer rate."

Recla assumed that the transfer rate was constant and independent both of the temperature differences and the velocity of the gas over the surface.

Rankine on the other hand assumed that the transfer rate, while independent of the velocity of the gas, was proportionate to the temperature difference and expressed the total amount of heat absorbed as proportional to the square of the difference in temperature.

Neither of these assumptions has any warrant in either theory or experiment and are only valuable in so far as their use determines formulae that fit experimental results. Of the two Rankine's assumption seems to lead to formulae that more nearly represent actual conditions.

Prof. Osborn Reynolds, in a short paper reprinted in Vol. I of his "Scientific Papers," suggests that the transfer rate is proportional to the product of the density and velocity of the gas and it is to be assumed that he had in mind the mean velocity, density and temperature over the section of the channel through which the gas was assumed to flow. Contrary to prevalent opinion, Prof. Reynolds gave neither a valid experimental nor a theoretical explanation of his formula.

The above deductions are all based on conductivity and heat transfer in boilers.

Conductivity of air	$.0122\ (1 + .00132T)$
Conductivity of carbonic gas	$.0076\ (1 + .00229T)$
Conductivity of superheated steam	$.0119\ (1 + .00261T)$

T—is temperature in degrees Fahrenheit.

No account in any of the above has been taken of radiation of heat from the gas. Since the common gases absorb very little radiant heat at ordinary temperatures, it has been assumed that they radiate very little at any temperature. This may or may not be true for boilers, but certainly a visible flame must radiate as well as absorb heat. However, this radiation may occur, since it would be a volume phenomena rather than a surface phenomena, it would be considered somewhat differently from ordinary radiation. It might apply as increasing the conductivity of the gas which however, independent of radiation, is known to increase with the temperature. It is, therefore, to be expected that at high temperatures the rate of transfer will be greater than at low temperatures. The experimental determinations of transfer rates at high temperatures are lacking.

Although comparatively nothing is known concerning the heat radiation from gases at high temperatures, there is no question but that a large proportion of the heat absorbed by a boiler is received direct as radiation from the furnace. E. Houbaer (Seraing, Belgium) calls attention as follows to the too marked tendency in the combustion gases to form an erroneous estimate of their value:

The conception of the "calorific power" of gases has no importance from the point of view of their value in use: it is, obviously, the sole absolute factor of these fuels, calculable either theoretically, having regard to their chemical composition, or practically, by calorimetrical methods. But their true value depends solely on the temperature of combustion, a factor impossible to determine definitely, in as much as it depends essentially upon the conditions under which that combustion occurs, and it is precisely those variable conditions which it is necessary to determine in order to obtain the greatest possible yield from the fuel employed.

With the object of affording concrete examples and of being able to base his arguments on such figures the author has ascertained them (by M. Le Chatelier's method) and under the variable conditions which may be met within practice, for three types of (1) blast furnace, (2) gas producer and (3) coke-oven gases, the chemical compositions of which are given below. The figures in the analysis show the average composition of the gases available at the Cockerill Works. The factors have been calculated in each instance, not on the assumption that the gases undergo neutral combustion, but with the admission of 25 per cent of air in excess.

Composition of the Gases.

Constituents	Coke Oven Gas	Producer Gas	Blast Furnace Gas
Hydrogen	57.00	12.00	3.00
Carbon Monoxide	6.00	19.00	26.00
Carbon Dioxide	2.00	8.00	11.00
Methane	23.00	2.00	....
Nitrogen	12.00	59.00	60.00

Coke Oven Gas.

Minimum calorific power	3761 calories
Minim. calorific power with condensed steam	4212 calories
Temperature of combustion (gas unheated (air heated to 600 degrees)	1940 degrees
Temperature of combustion (gas unheated (air heated to 1000 degrees)	2165 degrees
Temperature of combustion (gas unheated (air heated to 400 degrees)	1825 degrees
Temperature of combustion (gas unheated (air unheated	1600 degrees
Volume of air of combustion corresponding to one volume of gas (including) 25% excess	4.88 volumes
Volume of smoke	5.48 volumes

Blast Furnace Gas.

Minimum calorific power	873 calories
Minim. calorific power with condensed steam	891 calories
Temperature of combustion (gas unheated (air heated to 200 degrees)	1325 degrees
Temperature of combustion (gas unheated (air heated to 600 degrees)	1465 degrees
Temperature of combustion (gas unheated (air heated to 800 degrees)	1540 degrees
Temperature of combustion (gas heated to 600 degrees) (air heated to 600 degrees)	1695 degrees
Temperature of combustion (gas heated to 900 degrees) (air heated to 900 degrees)	1920 degrees
Volume of air of combustion corresponding to one volume of gas (including 25% excess)	0.91 volumes
Volume of smoke (including 25% excess)	1.76 volumes

Producer Gas.

Minimum calorific power	1068 calories
Minim. calorific power with condensed steam	1135 calories
Temperature of combustion (gas heated to 600 degrees) (air unheated)	1530 degrees
Temperature of combustion (gas heated to 600 degrees) (air heated to 400 degrees)	1680 degrees
Temperature of combustion (gas heated to 600 degrees) (air heated to 600 degrees)	1760 degrees
Temperature of combustion (gas heated to 900 degrees) (air heated to 900 degrees)	1980 degrees
Volume of air of combustion corresponding to one volume of gas (including 25% excess)	1.22 volumes
Volume of smoke (including 25% excess)	2.06 volumes

This puts us in possession of the factors necessary for the comparison of these fuels. In order to throw into relief the valuelessness of the conception of the calorific power, the temperature of combustion of the producer gas with 1,068 calories may be instanced when the gas and air are heated to 900 degrees, that is to say 1,980 degrees as compared with the temperature of combustion of the coke-oven gas, with 3,761 calories, which is only 1,940 degrees when this gas is employed cold and the air of combustion is heated to 600 degrees.

In short, it is obvious that in such a case when high temperatures of working are necessary, it is better to employ a gas capable of giving very high temperatures of combustion.

Mr. Houbaer states in his discussion of the use of coke-oven gases in the open hearth furnace the principal advantages are as follows:

1. Increase in the production.
2. Simplification in construction.
3. Diminuition in the repairs, particularly as regards the ports and chambers.
4. Possibility of using a cheaper charge.
5. Ease with which the operation can be conducted.

Examples from the Cockerill Steel Works, show an increase of 34 and 23 per cent respectively in tonnage over using producer gas as a fuel (12-ton furnace). He states further: "The utilization of a gas with a higher temperature of combustion allows of greater economy in the pig iron in the charge; at the above works the average percentage of pig iron has fallen from 31 to 20 per cent by employing coke-oven gases instead of producer gas."

Prof. W. A. Bone (Imperial College of Science and Technology, London) in the discussion of the paper by E. Houbaer on the "Utilization of Blast Furnace and Coke Oven Gases in Metallurgy," before the British Iron & Steel Institute in 1913, said:

The question of the temperature of combustion is one of the most intricate and important which could be raised in connection with the subject of flame.

Of all the factors which might contribute to the determination of flame temperatures, initial temperature of the system, energy developed in combustion, specific heats of burnt gases, the question of the mechanism and duration of the chemical change in combustion and the question of radiation from the flame, must also be considered, as both factors would affect the temperature realized.

The expression "temperature of flame" conveyed to his mind very little meaning when flame in bulk, and not merely local temperature was in question. A mixture of unburnt gas and air might be taken as representing so much potential energy which could be liberated—not necessarily wholly as sensible heat when chemical change occurred and the burnt gases were formed. The energy liberated might be divided into two parts—namely, (1) the energy emitted by direct radiation and (2) the energy immediately communicated to the burnt molecules as kinetic energy (that was as sensible heat) which determined the temperature of the flame.

The modern conception of the process of explosive combustion was that at the moment when a system of molecules entered into chemical change and during the moment of chemical change, if he might use that expression—a sort of vibratory system was formed. For instance taking the simplest case and supposing hydrogen was being burnt, the hydrogen and oxygen molecules came together by collision and for an instant, which was indefinibly short, but which was very important from the point of view of the ultimate result there was formed not steam but a vibratory system of hydrogen and oxygen. Such a system was in a state of intense vibration and during its transitory existence would omit a considerable amount of radiant energy which would not therefore be manifested as sensible heat in the product. Then came the formation of steam and at the moment of formation the steam was, no doubt, still in vibratory condition. Finally as the result of collisions with the other molecules of steam and also with some of the inert gases, the system settled down to a steady nonvibratory state. The burnt products would now be in a state of very rapid translatory movement and would therefore be at a high temperature. He desired the members to bear in mind that the whole of the energy of the combustion was not imparted immediately to the products as kinetic energy (that was, as sensible heat). Therefore any calculations of flame temperature based simply upon total energy or total heat of combustion and the specific heats of the products would yield too high a result. Thus, for example, if in a given change 10 per cent of the energy was directly radiated off, then only 90 per cent would be immediately communicated to the products as sensible heat which determined temperature.

The subject of the radiation from flames was first studied scientifically by Robert von Helmholtz a good many years ago. Von Helmholtz, working on quite small flames, determined that from a coal-gas flame, 6 millimeters in diameter, 5 per cent of the energy was radiated; from a carbon dioxide flame 8 per cent, and from a hydrogen flame 3 per cent. Those numbers, however, only held good for small flames. There was no doubt that in a large flame more energy than that was radiated out and it was impossible to define absolutely—it could only be done relatively—the amount of energy directly radiated away in any given case. Radiant energy was very important in furnace operations, because in such operations it should be the object to heat as far as possible by radiant energy. The fact that carbon monoxide gave a better radiating flame than hydrogen might partly explain why in a furnace it was better to use a gas in which there was a higher percentage of carbon monoxide than one of equal calorific value in which there was a high percentage of hydrogen.

Some very important experiments were carried out in 1890 in Berlin by Julius, who showed from spectroscopic investigations that the whole of the radiation in flame was due to incipiently formed carbon dioxide and steam molecules and the amount of the radiant energy emitted by a given flame might be regarded as derived additively from the volume of steam and carbon dioxide produced by the combustion of unit volume of the gas. Thus, in a certain series of experiments upon the amount of radiation emitted from a number of different flames, Julius formed a value of 74, which was simply an arbitary and relative number for a hydrogen flame per liter of gas burnt, for a similar carbon monoxide flame he found a value of 177 per liter, from which it appeared that a carbon monoxide flame emitted nearly two and half times as much radiant energy as a hydrogen flame of the same dimensions. In the case of a methane flame he similarly obtained a value of 327 per liter; on the supposition that that was the addition derived from the amount of carbon dioxide and steam produced during combustion, that number should have been 177 plus 2 times 74 or 325, which closely agreed with that actually observed. For all other hydrocarbons, or mixture of gases, the same relation was found to hold good.

In forming any estimate of flame temperatures under given conditions, it is evident that the question of radiation must be taken into account. As a further example, it has been proved in experiments upon internal combustion engines that the fact of making the inside of the engine cylinder reflecting, for instance, by silver-plating, it raised by about 5 per cent the maximum pressure of explosion and therefore the power developed from the gas. That was due to the fact that the radiant energy was not absorbed by the walls of the gas engine so quickly as it would have been with blackened walls, but that it was reflected through and through the gases and gradually absorbed by combustion products.

Prof. H. LeChatelier in the journal of the Iron and Steel Institute (1919) for discussion on Fuel Economy Papers wrote as follows:

"The manipulation of steel furnaces with heat recuperation was an exceedingly delicate operation, owing to the very small differences which existed between the fusion points of the refactory materials and that of the steel. The best bricks, which were silica bricks, fused at 1,700 degrees "C" while the temperature of dead soft steel had to be, at the time of pouring 1,600 degrees at least. Its solidification point was about 1,550 degrees "C," and it was at least necessary to have an excess temperature of 50 degrees to be able to pour it into a ladle and from the ladle into the molds before solidification commenced. The mechanism of the heat exchanges between the flame and the heated metal was such, however, that under ordinary conditions in regenerative furnaces the roof (radiation from which served as a medium for that exchange) required to be at a considerably higher temperature than the bath. The combustible gases arriving in the furnace were deprived of all illuminating power and therefore possess a negligible emissivity. On leaving the producer they contained only a very small amount of hydrogen carbides—3 per cent of the methane at most and that compound was destroyed during the passage of the gas to the recuperators, as much by the action of the heat alone as by that of the water vapor and the carbonic acid. Those gases, at the moment of combustion, practically contained only hydrogen and carbon monoxides and burned with a flame giving hardly any luminosity and radiating but very little heat. The greater part of the heat was exchanged by convection, that was to say, by the contact of the gas with the solid heated materials. It was for that reason that the ports were inclined so as to direct the jet of flame on to the bath of steel. Long before, however, the hot gases had yielded up the whole of their available heat, they ascended, owing to their lower density to the upper part of the furnace, that was to say, to the roof, to which in the end they yielded the greater part of their heat. The roof thereupon radiated the heat it had thus received on to the bath of the steel. To do that it had to be appreciably hotter than the bath, the more so as the heat had to be transmitted to the metal through the layer of slag which covered it. Stefan's law allowed of the quantities of the heat thus radiated being calculated. For a black body the quantity of heat radiated by 1 square centimeter of a body at absolute temperature T from a semi-sphere at temperature T° was given by the formula:

$$Q \text{ equals } 1 \times 36.10\text{-}12\ (T^4 - T^{04})$$

in which Q was the calorie-grammes per sec.

If the temperature of the roof were assumed to be 1,700 degrees C., and that of the surface of the bath 1,600 degrees C., that was to say a difference of 100 degrees, it would be found that the amount of heat received per square centimeter of the surface of the bath per second was 4 calorie-grammes.

It would be exceedingly important from the point of view of the conservation of the roof and indirectly from the point of view of the fuel consumption, to yield as much heat as possible directly to the bath without the intervention of radiation from the roof. It should then be possible to work the charge without letting the roof become hotter than the bath or if it would be preferred to maintain the actual temperature of the roof, to impart more heat to the bath per unit of time, which would accelerate the operations and proportionally diminish the amount of coal burned.

Two methods appeared worthy of trial.

1. To increase the emissive capacity of the flame by injecting directly into the furnace a small amount of tar so as to occasion a precipitation of solid carbon in the flame. The latter would thereupon directly radiate a portion of its heat on to the bath.

2. To deflect the hot flame already burned at the surface of the bath by means of jets of high pressure compressed air directed from the roof of that half of the furnace situated at the outlet end of the gases. In the first half of the furnace such jets would not be necessary as the flame would be already inclined towards the bath owing to the inclination of the ports, besides which the current produced by such jets would too greatly accelerate combustion and give too short a flame. The higher the pressure of the air thus blown in, the less would be required to deflect the hot gases towards contact with the bath and assist heating by convection. It would be important naturally, not to cool down the flame. Economy of fuel could only result from the employment of the most accurate proportion of air for combustion.

The authors of the paper on Fuel Economy, Professor William A. Bone, Sir Robert Gadfield and Mr. Alfred Hutchinson took exception and did not agree with one of the points in Prof. LeChatelier's communication.

Prof. LeChatelier had rightly drawn attention to the importance of radiation from the flame of the gases burning in open hearth furnaces, but he was wrong in stating that, inasmuch as those gases practically contained only hydrogen and carbon monoxide, they burnt with a flame radiating but little heat. Also, it was questionable whether the emissivity of a flame would be much (if at all) increased by injecting into it a small quantity of tar so as to occasion a precipitation of a solid carbon. As a matter of fact, scientific investigation had proven that the principal source of radiation from flames was incipiently formed CO_2 and H_2O molecules which, at the moment of their birth, were in a highly vibratory condition. A CO flame radiated about 2.4 times as much energy as did an H_2 flame of the same dimensions; and the emissivity of a Bunsen coal-gas flame was not materially increased by cutting off its primary air supply altogether. The whole subject of radiation from flames had been fully dealt with in the third report (1910) of the committee of the British Association appointed for the investigation of gaseous explosions, a perusal of which would help furnace managers to understand the cause of radiation from flames and its dependence upon (1) the size of a flame (particularly area), (2) its degree of areation, and (3) the chemical composition of the gas burnt.

The following is given from this report:

In the investigation of combustion of gases at high temperatures one factor relating to surface combustion must be considered in connection with the influence of moisture.

Prof. Dixon found 30 years ago that dry carbonic oxide and oxygen were not inflamable.

Dr. Bone had found that carbonic oxide, thoroughly dried, accelerates surface combustion in a very marked degree. If he took a mixture of carbonic oxide and oxygen and saturated it with (say) 1½ per cent of moisture a certain value would be obtained, i. e. a certain amount of gas would disappear in a given time. If this mixture were thoroughly dried, it would be found that the value obtained before was about doubled. In other words, the removal of the trace of moisture had the effect of very greatly accelerating the action of the surface in bringing about the combustion of the carbonic oxide.

Prof. Callendar in a paper before the Royal Society in 1906 found with a Bunsen flame, with air and gas adjusted as nearly as could be estimated in the proportion required for complete combustion, the proportion of heat radiated varied from 10 to 15 per cent for flames from 1 to 4 inches in diameter. As the air supply was reduced for the same rate of gas consumption the size of the flame increased and also the amount of heat radiated. A maximum of 15 to 20 per cent was reached for these burners when a brilliant well-defined inner cone was formed. If the amount of air supplied was in excess of that required for complete combustion the radiation fell off considerably in consequence of reducing in size and fall in temperature of the flame. Reducing the air supply the temperature was reduced and radiation fell 12 to 16 per cent. With steady luminous flames, there was a considerable increase of radiation on excluding air from the flame. With small flames of low temperature the proportion of heat radiated might be as low as 2 or 3 per cent.

These experiments indicate that radiation depended largely upon the size of the flame as well as on the temperature and on the presence of CO or solid C, when the air was insufficient for complete combustion.

Data representing British practice in the years 1914-5. The identity of each firm is concealed by a distinctive Roman numeral.

The following descriptive terms were used:

"Molten Pig Processes" } Where 85% (or more) of the total metal charged was made up of molten pig iron from the blast furnace.

"Mixed Processes" } Where the proportion of molten pig iron in the charge varied between 40 and 70 per cent, the remainder of metal (pig and scrap) being cold.

"Cold Processes" (when no molten metal at all was charged)

Summary of Results.

	Cwt. coal per ton of ingots	Average cwt.
(a) Molten pig processes.....	6.00 to 7.00	6.35
(b) Mixed processes	6.25 to 8.75	7.65
(c) Cold processes	7.00 to 12.00	9.45

Coal Consumption in British Steel Works "Molten Pig Processes"

	Metal Charged Per Ton of Ingots Made.				Actual consumption at steel works per ton of ingots rolled into finished sections.					Coal consumption at B. F. and coke ovens per ton of ingots rolled into finished sections.			
					(A)	(B)	(C)	(D)					
Firm No.	Molten pig iron cwt.	Cold pig iron cwt.	Cold scrap cwt.	Types and Sizes of Open Hearth Furnaces	Open hearth furnaces cwt.	Soaking pits or reheating furnaces cwt.	Rolling Mill cwt.	Other furnaces	Total cwt.	At coke ovens cwt.	For calcining and other purposes cwt.	Total cwt.	Grand total cwt. of coal consumer per ton of ingots from ore to finished steel sections.
VI	16.16	1.63	0.13	Basic 7 x 55 tons 2 x 65 tons	6.36	1.46	2.44	1.79	12.05	28.70	2.65	31.35	43.40
VII	17.5	Nil.	1.73	Basic 1 x 250 tons Talbot 2 x 60 tons Wellman	6.09	Nil B. F. and C. O. gases used		4.76	10.85	27.77	3.03	30.80	41.65
VIII	17.5	Nil.	2.00	Basic Talbots 100-175 tons	6.00	3.50	3.50	2.00	15.00	40.00	Nil.	40.00	55.00
IX	17.0	Nil.	3.25	Basic 4 x 45 tons Producing High-Grade Alloy **Steels**	7.00	3.0	Nil. B. F. Gas Used	1.65	11.65	38.25	Nil.	38.25	49.90

Coal Consumption in Steel Works Using "Mixed Processes"

	Metal Charged Per Ton of Ingots				Actual Coal Consumptions at Steel Works per ton of ingots rolled into finished sections.						
					(A)	(B)	(C)	(D)			
Firm No.	Molten Pig Cwt.	Cold Pig Cwt.	Cold Scrap Cwt.	Types and Sizes of Open Hearth Furnaces	Open Hearth Furnaces and Mixed Cwt.	Soaking Pits and Reheating Furnaces Cwt.	Rolling Mills Cwt.	Other Purposes	Total Cwt.	Coal required at coke ovens and blast furnaces to produce the pig iron used cwt.	Grand Total of Coal Consumed Cwt.
XII	8 to 10	2.0	10 to 8	Basic 6 x 45 tons 2 x 60 tons	6.25	3.05	1.5 Partly Driven by Gas	Nil.	10.80	21.0	31.80
XIV	14 to 15	Nil.	6.0 to 6.5	Basic 2 x 25 tons 1 x 40 tons 1 x 50 tons 2 x 60 tons	8.75	5.1	5.50	Nil.	19.35	25.70	45.05
XVI	12.4	0.8	6.7	Basic ?	8.00	2.75	2.50	0.60	13.85	22.40	36.25

Coal Consumption in Steel Works Using "Cold Processes"

Firm No.		XV	XXII	XXIII	
Metal charged per ton of ingots.	Cold-pig, cwt.	11.5	12.0	9.4 to 11.0	
	Cold-scrap, cwt.	12.5	9.0	11.0	
Types and sizes of open hearth furnaces used		Basic 14 tons	Acid 2 x 30 tons 2 x 22 tons	Acid 1 x 50 tons 3 x 40 tons	Basic 5 x 50 tons
Actual coal consumption at Steel Works. Cwts. per ton of ingots rolled into finished sections.		Cwt.	Cwt.	Cwt.	Cwt.
	(a) Open hearth furnace and mixers	9.75	12.00	7.00	9.00
	(b) Reheating furnaces, etc.	2.00	4.50	8.25	8.25
	(c) Rolling mill	3.75	4.00	3.75	3.75
	(d) Other purposes	3.00	1.25	1.25	2.00
Total Cwts.		18.50	21.75	20.25	23.00

		Percentage Composition of Waste Gases				Average Temperature
Firm No.	From	CO_2	CO	O_2	N_2	C°
VI.	Open hearth furnaces	9.2 to 14.3	Nil	4.5 to 8.0	80.8	550°
	Soaking Pits	7.5	Nil	10.6	82.9	350 to 600°
	Boilers Gas Fired	17.9	Nil	4.9	71.2	600
	Boilers Coal Fired	11.6	Nil	7.4	81.0	237
IX.	Open Hearth Furnaces	10.15	Nil	6.0	83.85	400°
	Boilers	12.95	Nil	5.15	81.90	250°

		Percentage Composition				Temperature
Firm No.	Gases From	CO_2	CO	O_2	N_2	C°
XII.	Open Hearth Furnaces	9.5	Nil	8.8	81.7	480 to 870°
	Coal Fired Boilers	12.0	Nil	7.25	80.75	300 to 350
XIV.	Open Hearth Furnaces	8.0	Nil	9.5	82.5	525°
	Soaking Pits	4.0	Nil	15.0	81.0	480
	Reheating Furnaces	5.6	Nil	13.0	81.4	320
	Boilers	5.9	Nil	10.8	83.3	350
XVI.	Open Hearth Furnaces	12.30	Nil	8.65	79.05	620°
	Reheating Furnaces	13.60	Nil	8.65	79.05	200
	Boilers	12.0 10.2	Nil Nil	8.65 8.65	79.05 79.05	210 260

		Percentage Composition				Temperature
Firm No.	Waste Gases From	CO_2	CO	O_2	N_2	C°
XV.	Open Hearth Furnaces	9.8	...	8.8	81.4	655°
	Reheating Furnaces	13.4	...	4.2	82.4	590
XXII.	Reheating Furnaces	12.0	Nil	4.2	83.8	565 to 785
	Boilers	6.8	Nil	11.0	82.2	385
XXIII.	Open Hearth Furnaces	CO_2 = 6.00 to 11.60				475 to 500°
	Reheating Furnaces	CO_2 = 6.00 to 10.00				273
	Boilers and Economizers	CO_2 = 8.40 to 10.40				260

Heating Furnaces and Annealing Furnaces

Critical Comparison of Pair (Sheet Bar) and of Mill Type Furnaces—Sheet Bar Furnaces Are Continuous.

By W. TRINKS

PART XXIX.

IN the preceding installment mention was made of the fact that very little change has been made in sheet and tin plate furnaces, but that sheet bar furnaces had been made continuous, because sheet bars lend themselves somewhat better to mechanical handling than sheets do. It is not feasible to lay sheet bars down flat on a hearth and to push them along, because they would climb over each other. The bars must be placed in a different position for successful pushing. This problem has been solved in two different ways by Allis and by Costello.

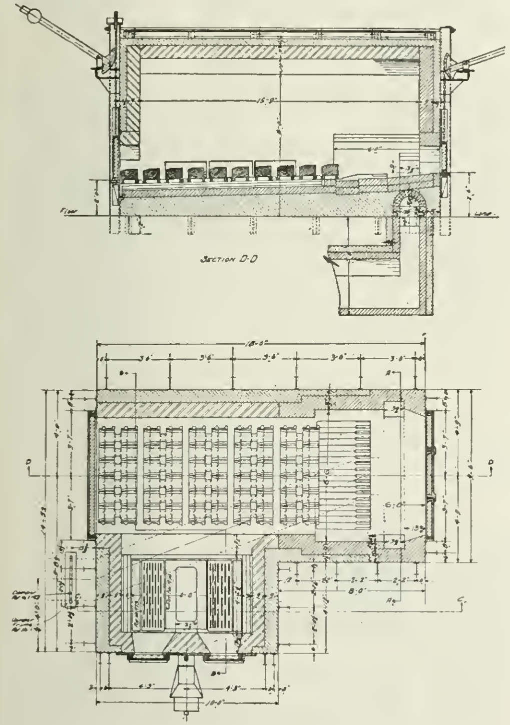
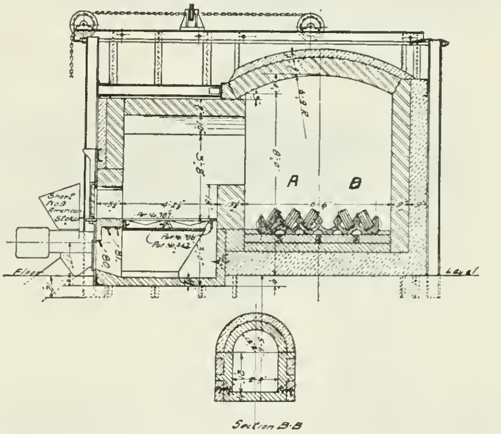


Fig. 220.

The Allis furnace is shown in detail in Fig. 220 and in a more general manner in Fig. 221. It is built by the G. J. Hagan Company, Pittsburgh. The sheet bars are laid in inclined piles on a rack outside the furnace, between the latter and the pusher. See Figs. 221 and 222. A motor operated pusher shoves the bars into the furnace and pushes all of the other piles ahead. Alternate rows of bars stand in different directions. If those on the outside rack slant upward to the right, as in Fig. 222 or at *A* in Fig. 220, the bars in the charge ahead slant upward to the left, as at *B*, in Fig. 220. The sheet bars are crossed at the point of contact between succeeding charges, and climbing over each other is positively prevented. The bars are finally pushed on a sort of forehearth, where the heater can spread them out for the purpose of obtaining an absolutely uniform temperature. The very existence of this forehearth seems to indicate that the bottom bars of each pile are not heated as highly as the top bars and that a temperature equalizing forehearth is desirable.

As a rule Allis furnaces have been fired by stokers, but any other method of firing which will not injure the sheet bars is equally well adapted. It will be noted from the illustrations that the firebox is at the pusher ends and that the flue gases leave at the other end, where the sheet bars have their highest temperatur. This arrangement makes for a fairly uniform temperature in the furnace and protects the bars from being overheated. However, it does away with the fuel saving feature of the counter-current continuous furnace. It is also evident that the location of the firebox to one side results in a one-sided temperature distribution, which is, however, somewhat equalized by radiation.



The principal advantage of the Allis furnace is, of course, the labor saving feature. On the other hand it is claimed, by some mill managers, that this is a rather imaginary advantage, because the wage schedule calls for a given wage per ton for heating regardless of the type of furnace. The before-mentioned mill managers reason that, if you pay a man a good wage for heating, you might as well make him work for it, particularly if the labor saving furnace costs considerably more than the ordinary furnace on account of the royalty which must be paid on its patented features. Another feature which is complained of occasionally, but which can hardly be of deciding importance, is the amount of sheet bars left at the end of a turn (or shift). Heaters object to leaving so much steel in a furnace at the end of a turn. It is obvious that no steel is being removed from the Allis furnace while a heat is being worked out from the sheet furnace. In other words the continuous furnace is somewhat limited in value, if the charging and removing must necessarily be intermittent.

The latter objection, as well as some of those before mentioned, apply also to the Costello furnace which is shown in Fig. 223. It will be seen that this furnace (which is built by Tate-Jones & Co., Pittsburgh) has some advantages over the Allis furnace. The heating chamber is at the side, just as it is in the Allis furnace, but the furnace is narrower, which fact helps to produce a uniform temperature distribution. The hot gases sweep over the sheet bars and return underneath; in consequence, the fuel is used to better advantage. The sheet bars stand on edge, except the last few near the discharge door. The result is that some of the gases or products of combustion filter through between the bars and heat them more uniformly all of the way through. It might be thought that this statement refers to the center part (between the skid pipes) only and that uniform heating of the overhanging ends could be obtained only by taking a few bricks out under the skid pipes, thus offering a short circuit to the hot gases. However, it is claimed that the heating is equally uniform with and without these auxiliary openings. It is evident that the sheet bars will topple over near the discharge end, and that the last one will lie flat. This circumstance is quite liable to produce climbing and piling. However, the nearness of the discharge door allows straightening up of the trouble with little effort.

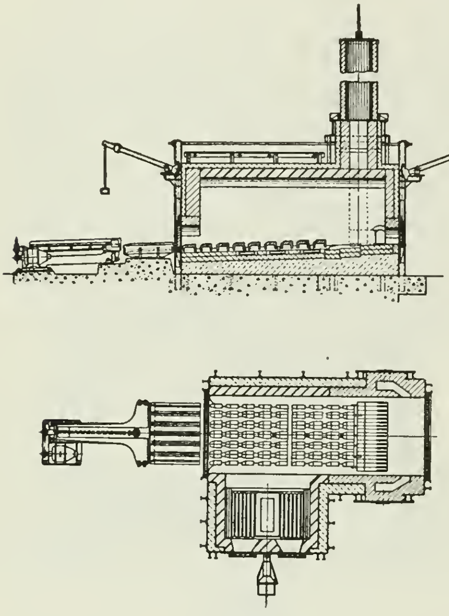


Fig. 221.

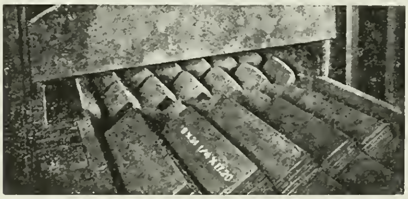


Fig. 222.

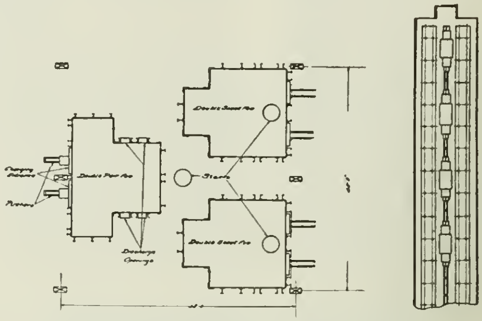


Fig. 224.

The Costello furnace is open to the objection which is common to all furnaces with water cooled skid pipes, namely, "black spots." However, this trouble is considerably reduced, and almost entirely eliminated, in the present furnace, by making the skid pipes double, which means that a small water cooled pipe lies inside a larger pipe which is indirectly cooled by the smaller pipe. It is claimed that this design does away with black spots.

The Costello furnace requires good combustion practice if the bars are to be kept from scaling, because it makes the products of combustion circulate around the bars and percolate between them, while in the Allis furnace, heating occurs mainly by radiation, and less by direct contact between gases and steel.

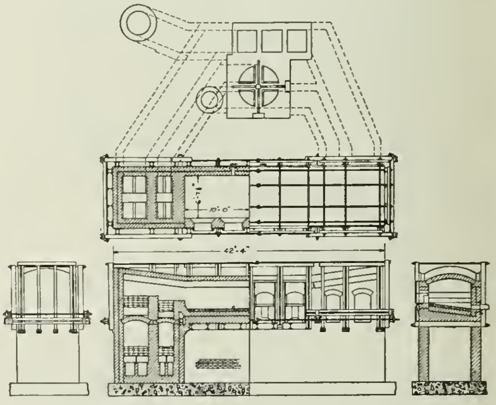


Fig. 225

The arrangement of Costello continuous pair furnaces in relation to sheet furnaces and to the mill is shown in Fig. 224.

The last group of furnaces which will be subjected to a critical comparison, is that of mill type furnaces, or "reheating furnaces." These furnaces heat semi-finished material such as blooms, billets, slabs or beam blanks. Although it is commonly known, it may be advisable to repeat here that for numerous reasons it is frequently impossible to finish steel sections in one heat from the ingot. In that case the semi-finished material is charged cold and is brought up to 2200 or 2250 degrees F. in "reheating furnaces".

Two general types are used, namely, "in-and-out" furnaces and continuous furnaces. The meaning of the two terms is clear from former articles. Either one of the two types can be built with or without means for preheating combustion air by means of the escaping products of combustion, using either regeneration (see Part VIII) or recuperation (see Parts VI and VII).

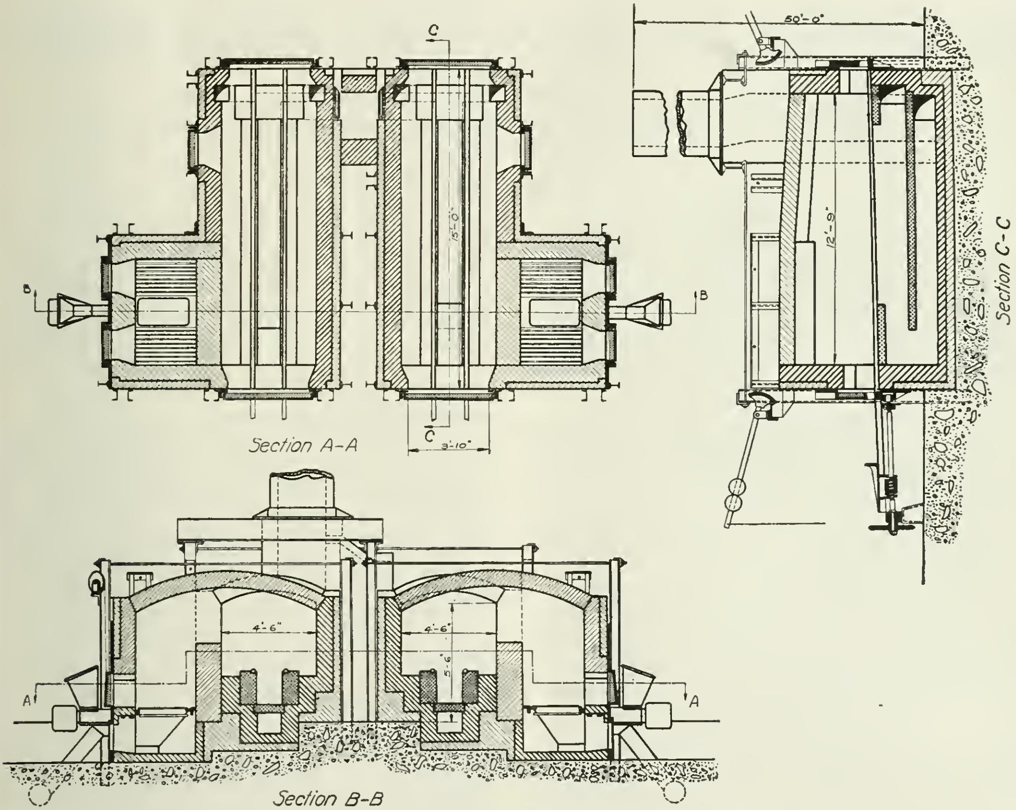


Fig. 223.

The plain in-and-out furnace without regeneration or recuperation, which is so common in forge shops, can be found but seldom in modern rolling mills, because of the high fuel consumption. There are, however, some exceptions to this general fact. Whenever coal is used as fuel, either on the grate or else in the shape of powder, preheating of air is impracticable, unless the degree of reheating is extremely small. With coal on the grate, preheat, sufficiently high to be of value, interferes with the cooling of the grate bars and results in burning out of the bars. With powdered coal, blowing or transportation air (which roughly equals one-half of the total air) cannot be preheated. Besides, recuperators and regenerators are clogged up by the ash contained in powdered coal. This latter fact depressing the efficiency of coal fired in-and-out furnaces and limits their applicability to localities in which coal is very cheap. This statement does not apply to low temperature furnaces such as sheet furnaces or annealing furnaces.

Mill type in-and-out reheating furnaces are, as a rule, of the regenerative type, if natural gas, water gas, coke oven gas, producer gas or blast furnace gas serve as fuels. An example of a regenerative furnace for producer gas is shown in Fig. 225.

The question naturally arises, "under what conditions is the use of that type of furnace advisable?" The answer is best given negatively in this manner: "Whenever it is impossible to use a continuous furnace". In detail, this means that it is used wherever varying shapes or sizes must be handled or with sections which do not lend themselves to being pushed through a furnace. General utility mills, rolling a variety of sections, are almost invariably equipped with in-and-out furnaces. The regenerative in-and-out furnace is likewise used in the heating of skelp and tubes.

The type of furnace under discussion has several undesirable features. The hearth space between the doors is more or less unavailable, particularly in the heating of large sizes which require a charging machine. This fact reduces the capacity of the furnace and causes the designers to keep the posts between the doors quite narrow. But narrow posts have no strength, and collapse, either from unequal expansion or from impact during charging or emptying. Besides, flame passes out around the doors, and the binding of narrow posts is soon burnt away. For this reason it is not safe to figure on heating more than 60 or 70 pounds of steel per square foot an hour. It is desirable to make the roof low on the side away from the doors and to pass more flame along the door side than on the far side, in order to produce uniform heating.

Regenerator chambers are more or less of a nuisance, first, because they gradually clog up, and second because faulty reversing or careless firing-up produces explosions which either wreck the regenerators or else cause them to be leaky, which condition reduces their efficiency to a considerable extent. The upkeep of the regenerator is another item which must be taken into consideration. Cost figures on this item vary in wide limits on account of different fuels, different conditions of ground water level, and different amount of care taken in operating the furnaces.

Economical Firing of Steel Plant Boilers

Comparison of Handfired, Stoker Fired and Powdered Coal Fired Boilers—A Complete Test Recently Run on a 520 H.P. Boiler Fired by Powdered Coal Is Included.

By CHARLES LONGENECKER

IN any comparison of firing methods it is logical that the principles which obtain in burning coal be first discussed. Knowing these principles, it is a simple matter to observe how their application is carried out in a furnace if it be hand fired, stoker fired or fired with powdered coal. Boilers can be divided into two classes; those on which the load is constant and those having a variable load. For the first named class the firing conditions are comparatively simple and the requirements are:

1. A steady and uniform feed of coal.
2. An unvarying air supply properly distributed.
3. Ash removal which shall not interrupt heat generation
4. Means for effecting the above features which in itself shall function uninterruptedly.

Where the load varies the demands are for:

1. A fuel feeding method which shall readily respond to the fluctuating demands.
2. An air supply which shall synchronize in proportion to the quantity of fuel fed.

The third and fourth features are the same as for boilers with a constant load. Other features which, while not connected with the burning of the fuel in the furnace, are nevertheless controlling ones, are those which determine the economical operation of the unit. These are labor cost, repair cost, coal handling cost, etc. In considering these principles it is presupposed that the furnace design is appropriate to whatever method may be employed. Another consideration which must be borne in mind is that a fuel bed is not of a homogeneous nature.

The simplest method for firing boilers is naturally hand firing. Due to lack of economy this method should be employed only in cases where the boilers are of low horse power and a high rating not desired. It is physically impossible to fire boilers of large horsepower by hand with any degree of efficiency. From another viewpoint hand firing is permissable where the cost of the installation of more economical means is not justified by the saving secured.

The disadvantages of this method are high labor cost, low evaporation per pound of coal, likelihood of a fluctuating steam supply, impracticable on boilers of large size. The advantages are simplicity and elimination of initial cost for equipment for mechanical firing. The tendency of today in boiler operation is to do away with the "human element" as far as possible. This has given rise to the invention of numerous schemes for automatic boiler regulation. The uncertainties connected with hand fired boilers mitigate against its use and although there is less labor in either stoker or powdered coal firing, the aim at present is to reduce this supervision as much as is practicable. Other uncertainties are the supply of labor and efficiency of the labor that can be secured.

Hand firing is based altogether of course on the human factor and even where the firemen are the best there are physical limitations which determine the degree of success beyond which this method cannot go. It is impossible, however good the intentions, to feed the coal as uniformly as required. The opening of firing doors increases the excess air far beyond that theoretically demanded and the withdrawing of the ashes disturbs the bed and further increases the excess air. Should the coal be high in volatile matter a large portion of the valuable hydro-carbons will be lost due to the impossibility of getting a proper mixture of these with the air. Also the gases will be cooled before burning below the ignition point and hence will pass off as smoke. Holes in the fuel bed are hard to prevent in handfiring, and when they do occur it is extremely likely that they will not be observed. The advantages where furnaces are handfired are the low cost of equipment and the simplicity of the installation. The chances for interruption of service are reduced to a minimum as long as labor can be secured. The waste of fuel is high and will run from 25 to 50 per cent greater than is the case where stokers or powdered coal firing is employed. Labor cost is the principle item on the cost sheet and this with the loss of fuel must be balanced against first cost in considering any other firing method.

The desirable features where coal is burned on a grate are a fuel bed of even thickness and uniform composition and the ability to maintain these conditions. The stoker is more economical due to the fact that it more nearly approaches this ideal condition. It can readily be appreciated how hard it is to maintain these conditions in hand firing.

Concerning the limiting size of boiler which can be hand fired there is much argument. The Coal Trade Journal of December, 1919, states on this point: "This will depend a good deal on local conditions, but within reasonable limits we are able to get a figure which will fit the average case. The city of Cincinnati by ordinance limits the size of a hand fired furnace to 150 boiler hp. This size unit will have a grate surface 6 ft. wide by 6 ft. 6 in. long. It has been pretty well established in practice that a grate 6 ft. 6 in. or at most 7 ft. long is about the economical limit for a hand fired furnace. A longer grate than this will be very difficult for the fireman to handle. A furnace consuming 150 boiler hp is about the comfortable limit of a fireman's capacity. A 300 hp horizontal water tube boiler would have a grate surface not more than 7 ft. long and the width of the boiler would be about 10 ft. This is equivalent to two 150 hp hand fired furnaces under one boiler but is not good practice from the labor standpoint nor from the smoke standpoint."

The strength of draft and characteristics of the coal determining the thickness of the bed, but this thickness will generally run from 4 to 8 inches. The coal burned per square foot of grate surface per hour will average 25 pounds and vary from 10 pounds to 40 pounds under boilers whose horsepower averages 150. The rating developed on such boilers will vary but will usually be around 100 per cent. Average draft in the furnace will approximate .30 inches of water. The above relates to water tube boilers.

The inability of hand firing to meet the above specifications gave rise to the stoker and with the intention of improving on the stoker powdered coal firing has been brought forth.

There are no "hand and fast" rules as to which boilers should be hand fired and which should be stoker fired due to varying conditions but boilers from 200 hp up can readily be adopted to stokers. No one stoker will be suited to all varieties of coal but each will serve best with some particular variety. The characteristics of the coal which call for a variation in the type of stoker are the size of the coal, the fusibility of its ash, its coking powers, percentage of volatile matter and percentage of ash.

There are on the market several types of stokers known as hand stokers. These are as the name implies operated by hand and fed by hand but have features which are advantageous. The grate surface is sloping and the coal can be pushed forward as in a power operated stoker. The ash is dumped from the grate by operating hand levers. An ignition arch is usually sprung over the front of the grate which serves a very useful purpose. In one make of hand stoker the grate bars are inclined at an angle of 30 per cent. It is recommended for boilers of 500 horsepower or less and it is claimed that overload of from 75 to 100 per cent can be carried successfully using natural draft. In a test recently carried out on a hand fired stoker the following results were obtained:

Grate Surface	51.1 square feet
Calorific value per pound of coal as fired	12,990 Btu.
Dry coal per square foot of grate surface per hour	16.23 lbs.
Percentage of rated capacity developed	142.8%
Equivalent evaporation from and at 212 degrees per pound of coal as fired	10.77
Cost of coal to evaporate 1,000 pounds of water	0.247c
CO_2 in flue gases	10.2%

The earliest mechanical stoker was patented in 1841 and was of the chain grate type. This type of stoker is especially adopted to burn small size coal, and coke breeze, and fire burning coal high in volatile matter. An ignition arch is always provided to assure early ignition of the coal. Elasticity of feed is readily obtained by varying the thickness of fuel bed, the speed of the grate travel and draft in furnace. Fuel bed thickness will average 7 inches and grate travel from 4 inches to 12 inches per minute depending on boiler power demands. Chain grate stokers, are being used very extensively for burning the fine anthracite coal secured from the creeks and rivers which flow through the anthracite coal fields.

Besides the chain grate stoker the underfeed and sidefeed types are most frequently found. On boilers of large horsepower the multiple type underfeed stoker is most popular. Under such boilers one retort is provided for each 70 to 100 hp and capacities as high as 400 per cent of rating obtained. A rating of 500 per cent can be secured should enough retorts be installed. Probably the most authorative test on boiler of large size is that made by Dr. Jacobus at the Detroit Edison plant in 1911 (Trans. A. S. M. E., Vol. 33). Here Sterling boilers of 2365 hp rating equipped with 26 retort Taylor stokers gave an efficiency of 76 per cent at 200 per cent of rating and at 100 per cent rating the efficiency was 80 per cent. In "Power," June 23, 1914, the following are given as the controlling factors influencing the efficiency of a stoker.

1. The size of the unit.
2. Percentage of overload.
3. Character of coal.
4. The use of indicating boiler room appliances.
5. Intelligence of the fireman.

"The factor of most importance is, without doubt, the degree of intelligence which the fireman possesses and the interest he takes in improving operating conditions."

It is hard to see how there can be a much greater development of the stoker as it has its limitations beyond which it cannot go. One of these is the exposure of the parts to the intense heat of the furnace. At very high ratings the amount of coal burned per hour is great and the heat produced is correspondingly high. At high temperatures the ash fuses and is hard to dispose of properly and there is also liability of trouble arising from some coating of the tubes with the small particles of pasty ash. This ash is carried up by the gases which travel at a high velocity which is created by the increased air pressure demanded when large amounts of coal are burned. If larger boilers are built other means than the stoker must be employed to supply the coal. Whether larger boilers are practical is a debatable question but the trend has been towards increased size of units as is evidenced by the recent installation at the Ford plant. The boilers in this plant are of 2647 horsepower, and will be fired with blast furnace gas or powdered coal.

The mechanical power operated stoker unquestionably fulfills the requirements previously mentioned more perfectly than any other method other than powdered coal. With it the feed is uniform and the rate of feed can be varied as desired. The air supply more nearly approaches the theoretical and ash removal is regular and uninterrupted as long as the machinery is in operation. The limiting features are the coal characteristics and the conditions under which the particular type of stoker must operate. Certain types of stokers are adopted to burn certain varieties of coal and if for any reason a coal is obtained which has qualities other than those for which the stoker is adapted trouble may arise. Where forced draft is employed a high rating is easily obtained provided furnace volume is sufficient and the stoker will handle the increased amount of coal efficiently.

The use of powdered coal as a fuel for boilers is unquestionably making rapid headway. There have been many obstacles to overcome but this has been true in the solving of most engineering and metallurgical problems. When it is recommended that in 1913 the hourly coal pulverizing capacity of metallurgical plants was only 20 tons per hour it is evident that the industry is still very young in years.

Powdered coal firing takes precedence over the stoker in meeting the first two requirements before mentioned. The coal being in a fine state of division can be introduced into the furnace very uniformly and steadily and the air supply proportioned very closely to the theoretical. In all systems the coal is carried in a current of air from the burner so that intermixture can be very exact. The ash removal has occasioned much experimenting in order that it might be done successfully. The result of these experiments have proven beyond doubt that the correct disposal of the ash is a question of furnace design and draft regulation. For different coals alterations must be made depending on the burning characteristics. Interruption of feed is so seldom that it need not be considered as installations of the present day are mechanically very efficient. The lining feature for powdered coal firing is the size of the plant or the horsepower of the boilers. Where these total under 2,000 hp there is a question as to whether the saving will justify the cost of installation. There is no doubt but that this limiting feature will be overcome as progress in the art is made.

One of the greatest advantages connected with firing of powdered coal is the quick response which can be made to an increase or decrease in the load. By simply opening a valve it is possible to secure the immediate introduction of more fuel or to cut off the supply. This makes this method of burning coal very attractive, especially where the load fluctuates rapidly.

In a paper recently delivered by George T. Ladd before the Engineer's Society of Western Pennsylvania, the following statement is made in connection with the boilers, previously mentioned, as installed at the Ford plant. "The possible capacity ratings when burning powdered coal will be extremely high, as the firing equipment is of such a capacity as to burn completely sufficient coal to produce 400 per cent rating continuously. It is probably that a high percentage of efficiency will be maintained throughout the whole cycle of operation, as the efficiency curve when pulverized fuel is properly handled is very flat from 50 per cent to 400 per cent of normal rating. From the above, attention can logically be drawn to the high capacities possible with extremely large units when equipped for burning pulverized fuel as the main system of firing, without attempting consideration of the enormous furnace widths that would be required for stoker firing.

The following is a test recently run on a 520 hp boiler fired by powdered coal. This test was made to determine the results which could be expected under normal operating conditions.

Dimensions.

2.	Number and kind of boiler—1 Babcock & Wilcox.	
3.	Kind of furnace — Pulverized Fuel Burning Furnace.	
4.	Volume of combustion space per boiler	2,000 cu. ft.
5.	Water heating surface in boiler	5,201 sq. ft.
	(a) Water heating surface in economizer. (Ordinarily serve two boilers)	3,931 sq. ft.
6.	Superheating surface	943 sq. ft.
7.	Total heating surface of boiler	6,144 sq. ft.
	(a) Total heating surface of boiler and economizer	10,075 sq. ft.
	(b) Ratio of water heating surface of boiler to volume of combustion space	1 to .198
8.	Date	6-15-20
9.	Duration	23 hours
10.	Kind and size of coal	Bituminous coal

Average Pressures, Temperatures, Etc.

11.	Steam pressure by gauge	87.7 lbs. sq. in.
	(a) Barometric pressure	29.56 in.
12.	Temperature of steam	447.1 degrees
	(a) Normal temperature of saturated steam	329.4 degrees
13.	Temperature of feed water entering boiler	166 degrees
	(a) Temperature of feed water entering economizer	66.3 degrees
	(b) Increase temperature of water due to economizer	99.7 degrees
14.	Temperature of escaping gases leaving economizer	252. degrees
	(a) Temperature of gases, top of third pass	474. degrees
	(b) Temperature of gases, bottom of second pass	552. degrees
	(c) Temperature of gases, top of first pass	939. degrees
	(d) Temperature of bottom of combustion chamber	2312. degrees
15.	Draft between economizer and fan.	1.37 in.
	(a) Draft top of third pass	.35 in.
	(b) Draft bottom of second pass	.15 in.
	(c) Draft top of first pass	.02 in.
	(d) Draft in combustion chamber.	.26 in.
	(e) Blast pressure	5.72 in.
	(f) Differential pressure in blast pipe	5.64 in.
16.	State of weather	Cloudy and rain
	(a) Temperature of boiler room	90. degrees
	(b) Relative humidity of air entering furnace	80%

Quality of Steam.

17.	Number of degrees of superheat	117.7 degrees
18.	Factor of evaporation based on temperature of feed water entering economizer and degrees superheat.	1.251
	(a) Factor of evaporation based on temperature of water entering boiler and degrees of superheat	1.149
19.	Total weight of coal as fired	54,994 lbs.
20.	Per cent of moisture in coal as fired	.94%
21.	Total weight of dry coal	51,694 lbs.
22.	Ash and refuse (dry)	
	(a) Withdrawn from furnace bottom, tubes, flues and combustion chamber	2327.6 lbs.
	(b) Blown away with gas	6727.5 lbs.
	(c) Total	9055.1 lbs.
23.	Total combustible burned	42,637 lbs.
24.	Percentage of ash and refuse based on dry coal	
25.	Total weight of water fed to boilers	467,423 lbs.
26.	Equivalent evaporation from and at 212 degrees, based on temperature of water entering economizer, corrected for superheat in steam	584,746 lbs.
	(a) Equivalent evaporation from and at 212 degrees, based on temperature of water entering boiler	537,067 lbs.

Hourly Quantities and Rates.

27.	Dry coal per hour	2247.5 lbs.
28.	Dry coal per cubic foot of furnace volume per hour	1.123 lbs.
29.	Equivalent evaporation per hour from and at 212 degrees, based on water entering economizer	25423.7 lbs.
	(a) Equivalent evaporation per hr. based on temperature of water entering boiler	23350 lbs.
30.	Equivalent evaporation per hour from and at 212 degrees per sq. ft. of total heating surface, based on water entering economizer	2.52 lbs.

(Continued on page 336)

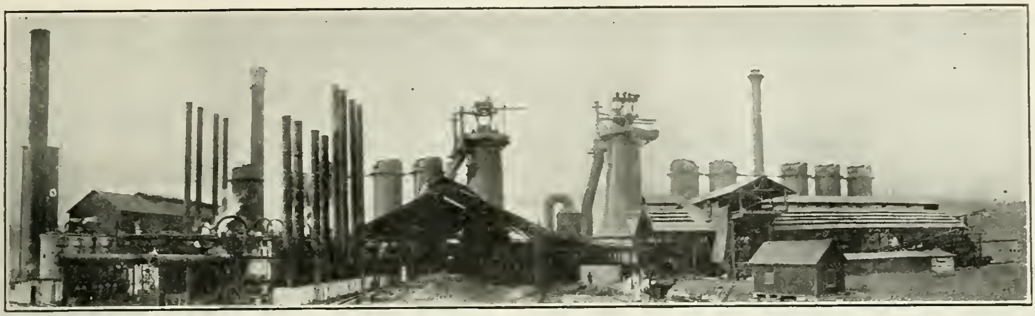


Fig. 1—General view of blast furnace plant.

The Alabama Company Nineteen-Twenty Improvements At Gadsden, Alabama

Improvements in Design, Lines and Distribution of Number One Furnace—New Storage Trestle—Locomotive Cranes—Installation of Pig Casting Machine—Labor Reduced From 305 to 160 Men.

By H. R. STUYVESANT,
General Superintendent, Blast Furnace Department.

FOR the past year the Alabama Company has been steadily improving its blast furnace plant at Gadsden, Alabama, near Birmingham. Number one furnace was of old design with petticoat, tuyere breast and hearth jacket spray cooled with a ditch encircling the hearth jacket and extending down to the level of the tapping hole. Cooling is not efficiently effected with this type of hearth, especially below the ditch. Practice shows that breakouts with this type of jacket are frequent. The breakout assumes more serious consequence on account of the jacket being surrounded by a ditch containing water. The iron coming in contact with the water causes violent explosions and heavy concussions with results which are disastrous as well as expensive. This danger has been so repeatedly demonstrated throughout the country that it was decided to eliminate the ditch entirely and abandon the idea of surface cooling.

Number one furnace was blown out October 19, 1920, and work of dismantling was immediately started. The shell was in good condition as were the foundation, columns and base plates. After removing the lining, the old iron work of hearth and bosh was dismantled, and five feet of iron, running silicon 1.25, sulphur .045, manganese .49 and phosphorous 1.11, was removed from the hearth, and the bottom built up with five courses of standard 18 x 9 x 4½ bottom blocks. No leveling was required to the furnace shell and mantle, as they were found to be correct.

Both on account of the inferior design of hearth and bosh construction, and on account of changing the lines of the furnace, entirely new iron and steel work was placed beneath the mantle as described.

The hearth section is of one and one-half inch rolled steel plate, butt strapped, riveted both externally and internally. Cast iron cooling plates, four inches in thickness, with two U tubes of one and one-half inch extra heavy pipe cast in same, are placed continuous about the entire circuit of the hearth jacket, extending to the bottom of the rolled steel hearth jacket. A small packing space was essential between the outside hearth jacket and the cooling plates, on account of the rivet heads on the steel jacket and the space between the butt straps. This space was packed tightly with a dry mixture of granulated slag and loam, the brick being laid solid against the cooling plates. Fire brick was built solid from outside bottom of hearth jacket to ground level, extending to center line of columns encircling the entire hearth jacket. This aids to further protection in case of possible failure of the high quality brickwork, workmanship, effective water cooling and mechanical strength. Enough clearance was provided for expansion to eliminate possible chance of side thrusts on the columns. Only a small run-off trough for occasional waste water is provided. To strengthen the bosh at the tuyere section a one and one-half inch rolled steel tuyere breast was used, being supported by the hearth cooling plates, holes being cut in for cooler and plate openings, as the most critical actions and highest temperatures are around this area. Strengthening at this section aids in the eliminating of so-called cinder breakouts, with which most every furnace man is familiar, especially where no protection to this section is provided except bosh bands. Three rows of cooling plates and ten tuyeres affords efficient cooling to this section.

The bosh bands, seven in number, are of one and one-half inch rolled steel. In order to prevent slipping of the bosh bands, forged steel bosh band supports were used which link the entire bosh band section together. The top band support is hung from the mantle ring, while the lower band support rests on the tuyere breast, dividing the weight of the bands between the mantle ring and the tuyere breast. Cooling is effected in the bosh section by seven rows of bronze cooling plates, 20 in each row. The bronze cooling plates were all arched over.

The cubical capacity of the furnace was slightly increased, the bosh was lowered and made steeper, the hearth diameter was increased, the batter of the inwall was increased, giving the furnace approximately 78 degrees bosh angle as compared with the pre-existing bosh angle of 74 degrees. The top, which is of Brown type, but of an old design was improved, the distribution was corrected by placing an extra receiving hopper with a throat extension between the skip and the revolving chute, thus causing the material to pass centrally through the throat of the new receiving hopper onto the revolving chute which now distributes the material on the big bell uniformally, irrespective of the position of the chute.

Improvements in design, lines and distribution of number one stack assures a much better and more economical working furnace, thus eliminating disastrous explosions from possible breakouts and assures an increased production, which necessarily reduces the operating cost.

The P. J. Brown Construction Company of Cleveland contracted the brick work. Harbison Walker Refractories Company furnished the brick for lining. The Variety Iron Works of Cleveland fabricated the hearth jacket, tuyere breast and bosh bands. The construction was done by the regular mechanical force, the designing and construction being in charge of the writer. Work on the furnace was completed January 1, 1921.

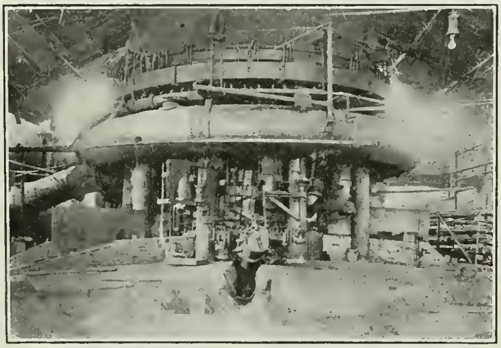


Fig. 2—Base of the furnace.

New Storage Trestle.

To insure a continuous run on both furnaces, eliminating the necessity of depending on the railroads to deliver raw materials, and as a further protection against mine and railroad troubles, a new permanent storage trestle was built and an ample supply of raw material stored for emergency needs. The trestle is designed so as to chute the materials to the side of same, eliminating the evil of filling the space under the trestle, this evil having a marked tendency to rot away the trestle and also requires excess labor in the recovery of materials. With the chute design of the new trestle the recovery of all material is available with locomotive cranes.

Locomotive Cranes.

Two 20-ton "Link-Belt" locomotive cranes are employed. Number one crane is equipped with a 36-inch Ohio lifting magnet and is used in the iron yard. Number two crane is equipped with a clam shell bucket and is used in general for handling ore, coke, stone, sand, ashes, cinder, etc.

Installation of Pig Casting Machine.

To insure a clean and uniform pig, both physically and chemically, together with doing away with the evils inherent in sand cast pig iron, a pig casting machine was installed. The installation includes a Heyl and Patterson pig casting machine of the most improved design of single strand Uehling type. The installation is so arranged that an additional casting strand can be readily installed to give a double strand casting machine, if necessary. The iron from the furnace is run into a ladle having a capacity of 75 gross tons. The ladle is of standard type with lifting trunnions. An overhead crane of Heyl and Patterson two-standard motor type, having a capacity of 55 net tons, tilts the ladle, pouring the iron into a runner which leads to the pig machine moulds. The flow of the metal is regulated to a nicety by the crane operator. The casting machine is driven by a 20 hp motor, cooling is effected by two lines of spray pipes over casting strand, the sprays extending a distance of 75 feet from the head of the machine. At the head of the machine the iron leaves the mould, passing directly through a chute into railroad cars. For cooling the iron after being loaded into cars a 35 foot steel trough is suspended over the loading track. The iron is then either shipped direct or transferred into other cars by a Link-Belt locomotive crane equipped with a 36-inch Ohio lifting magnet. In the event the iron is to be loaded into box cars, table chutes are provided in the iron yard for this purpose.

General.

In order to increase the efficiency of the locomotives and the locomotive cranes, assuring same in coaling up in the shortest possible time, a new coal storage with chutes was built.

A railroad track was extended into the boiler house in order that coal could be unloaded from cars directly at the point of use, also in order that ashes could be loaded directly into cars provided for this purpose.

All material storages, including sand, clay, coke braize, lime, fire brick, etc., were located at point of use, thereby eliminating the necessity of excess labor required for rehandling.

Two first-aid teams composed of six men each, have qualified in the work, having been instructed by a government agent.

In conclusion, from the foregoing improvements, organization and system, the pre-existing labor force of 305 men, required to operate two furnaces, was reduced to 160 men. However at present the company is operating its number two furnace only with 112 men as compared with 175 men formerly used to operate one furnace.

TUNGSTEN IN 1918.

A bulletin was recently received from the United States Geological Survey on "Tungsten in 1918." It discusses production, prices (their cause and effects) substitutes and the control of the world's supply.

By-Product Yield From Fifteen-Year-Old Coke Oven Plant

The Tuscaloosa, Alabama, Plant of the Semet-Solvay Company—Operated in Conjunction With the Central Iron & Coke Co., Still Maintain a High Efficiency in Production.

By W. L. GRAUL,
Semet-Solvay Company, Holt, Alabama.

STUDENTS of the by-product coke oven industry have shown increasing concern over the apparent inability of many of our coke oven plants to maintain satisfactory yields of by-products after the plants have attained an age of about eight years or more. It must be admitted that in many cases their concern is justified. Apparently the results expected were obtained from a plant only while it was comparatively new and continued operation in many cases resulted in a steady decrease of yields of the desired by-products.

However, recent records indicate that the relatively low by-product yields from a comparatively old plant are by no means unavoidable. An opportunity presented itself during the past summer to study carefully the operation and results on one of the oldest blocks of by-product ovens in the country. The situation came up in this way:

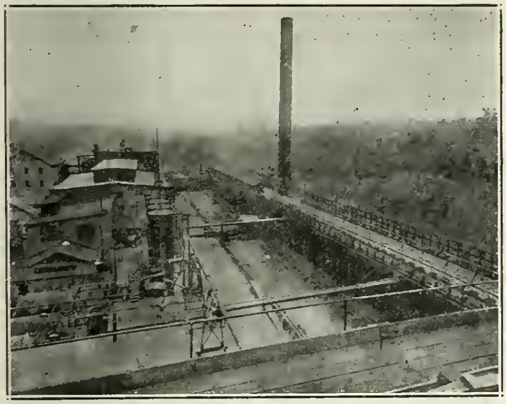


Fig. 1—General view of the plant.

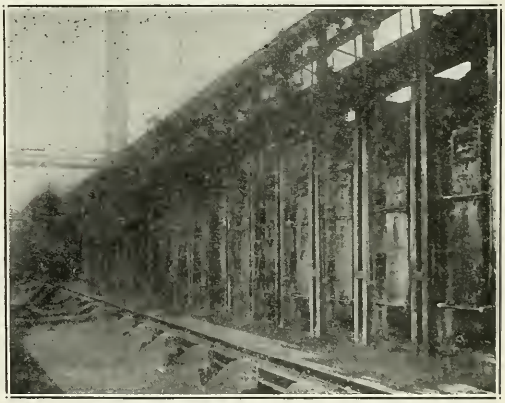


Fig. 2—Semet-Solvay ovens 15 years old.

The Tuscaloosa, Alabama, plant of Semet-Solvay ovens is operated by the Semet-Solvay Company in conjunction with the blast furnace operation of the Central Iron & Steel Co. Demands for coke decreased to such a point that it seemed advisable to shut down the more recently built block of 20 ovens, inasmuch as the output of the old block of 40 ovens was sufficient to meet requirements. This was done and during the months of June, July, August and September, 1920, under particularly trying weather conditions in Alabama, the old block alone was in operation.

This block was built in 1905 and consists of 40 of the then standard Semet-Solvay cold air ovens. They are five flues high, or about nine feet inside dimension, 35 feet long and from 16 to 17 inches wide, with a theoretical capacity of nine tons per charge. In this type of oven, a sole flue is provided, and the heat in the waste gases is recovered in waste heat boilers which furnish an ample steam supply for the entire plant.

In 15 years' operation, it has never been necessary to shut the block down for repairs to ovens or even linings. With this type of oven, such repairs as have been necessary, have been made by shutting down individual ovens for a few days without interfering with the operation of adjacent units.

The plant in general has gone through rather more than the usual vicissitudes developed by variations in demand for coke. Very seldom was it possible to maintain the same average rate of operation for two consecutive months. Market conditions have forced the operation to change from a pushing rate of only 15 ovens per day to 50, 60 or 85 in a comparatively short length of time. With these figures in mind, it will be seen that the plant certainly has not been favored by operating conditions.

The coal used is of excellent coking quality, and as will be seen in the table below, average about 30 per cent volatile matter. It differs, however, from the best by-product coking coals of the north in that instead of the usual low ash content of from four to seven per cent expected in the best northern coals, the coal used during the period in question averaged over 10 per cent ash. It may be remembered that in spite of this high ash content, the coke made at the Tuscaloosa plant, and iron made using it by the Central Iron & Coal Co. furnace were both awarded silver medals at the Panama Pacific Exposition.

Bearing in mind the age of the block in question, the fact that it has never been down for oven repairs, the extreme variations in operation to which it has been subjected, and the high ash content of the coal furnished it, the figures given below take on added interest.

	Coal			Yields		
Month	Percent Volatile	Ash	Total Coke	Ammonia (As lbs. Sulphate)	Gals. Light Oil	Gals. Tar
June, 1920	30.43	9.06	72.55	26.75	3.42	10.55
July, 1920	29.14	10.60	72.87	27.14	3.28	10.14
August, 1920	30.31	9.98	71.80	26.28	3.28	10.06
Sept., 1920	30.19	11.27	71.13	25.63	3.28	9.89
Average	30.02	10.23	72.09	26.45	3.31	10.16

These figures indicate returns not only much better than those reported from some batteries of different design constructed within the last 6 to 12 years, but also comparing well with the returns from some plants of very recent construction. The block was operated during the period in question at well over 100 per cent of rated tonnage and the ovens were taking a greater charge of coal than their theoretical capacity.

In spite of decreasing returns from some of the other plants, conclusions from a survey of all these factors in the performance of the Tuscaloosa Semet-Solvay block, would seem to prove that a decrease in by-product yields coincident with increasing age of a coke oven plant, has been, and can be, prevented by proper design, construction, maintenance and operation.

Every coke oven operator recognizes the necessity for proper operation and maintenance of his plant, since the results of mistakes along those lines are always painfully evident. Faulty construction is also generally very apparent sooner or later. Improper design is, however, more difficult to discover, due largely to the fact that the operator usually is too much concerned with the immediate necessity of making his plant produce results to worry over the question of whether or not its fundamental design is the best obtainable. It is only after a period of years has elapsed and the operating results can be compared with similar results from a plant of different type, that the problem of the best design is considered. It is perhaps unfortunate that such is the case, since the investment in a coke oven plant is relatively so large that the question of what design will give the best returns over a long period should be of paramount importance, but experience is always slow and sometimes costly and it only remains to use to the best advantage such experience as may be available.

This brief article has been written with that end in view—to furnish information concerning the actual results obtained, not during any particular test, but in the ordinary course of operation of a Semet-Solvay plant after 15 years of the usual coke oven plant operation.

The Donetz Region of the Bolshevic Government

By DIRECTOR M. ULLRICH.

PART II

NOTE—*We are recommending this article to the special attention of our readers. The author was employed in an iron and steel industry of the Donetz region and his work from September,* 1918, *to October,* 1920, *with the Soviet government of the Ukraine as assistant to the director consisted in furnishing technical material to the Donetz region. In this capacity he has had wonderful opportunity to become thoroughly acquainted with the conditions described by him.*

AT the present time, one blast furnace is in operation in the Russian-Belgium steel works in Jenakijewo and the second one in the Union in Makejewka. Here a few mills roll plates and structural material. In addition, one mill is running in the Kramatorskaja which produces billets, but the production of rolled material is so small that it cannot come anywhere near filling the tremendous want for plates and other rolled material. There is no wire for the production of nails which have disappeared entirely from the warehouses so that the necessary buildings and repairs cannot be made. On account of lack of wire no nets can be made for the safety lamps of the miners, so that the latter will very soon be compelled to work with unprotected lamps underground and to expose themselves to the greatest dangers. There is no foundry iron, and no pig iron suitable for open hearths, which cannot be produced in the required quality on account of the lack of the necessary raw material and of skilled workmen. It is true that in the large steel works there can still be found several million puds of pig iron scrap of unknown quality which cannot be used anywhere. Up to the present time the Bolsheviks have used the stores which were bequeathed to them by the Czar government but these now are almost entirely used up. Wages in the iron and steel industry have lately gone up tremendously as the following tabulation from the actual record from the Kramatorskaja steel works proves:

	Number of Workmen	Wages Paid per Month
July 1, 1919	2,262	885,775.00 Rubles
October 1, 1919	1,368	802,507.63 Rubles
January 1, 1920	1,440	759,188.00 Rubles
April 1, 1920	1,368	3,033,877.47 Rubles
July 1, 1920	1,454	6,094,611.65 Rubles

With that the production was very small.

	Number of Officials	Salary
July 1, 1919..........	308	279,000.00 Rubles
October 1, 1919......	251	242,000.00 Rubles
January 1, 1920......	251	368,000.00 Rubles
July 1, 1920.........	270	1,370,000.00 Rubles

In addition, this company was given for the period of January 1920 to June 30th an extraordinary subsidy of 76 rubles. In connection with this it must be remembered that the expenditures for equipment within this time are not included in the above mentioned figure. For the production of boiler tubes and of gas pipes, the pipe mill of Chaudoir in Jekaterinoslaw has been operated but this works produces almost nothing. Of course, all these works suffer from lack of coal. Works which are fortunate to have their own locomotives bring their coal from the coal region, but even the supply of these preferred works is interrupted very often. Last winter works which are very favorably located in the coal region and were considered as best producers were not in a position to supply their own coal requirements, but were required to shut down their electrical generating stations and to leave their whole works without light or power. Thus the whole condition of industry is undermined by the lack of coal and of raw material, by the breaking down of the transportation equipment and by the unwillingness of the workmen to do any work. The fruitless methods of administration by the bureaucratical authorities allow no improvements of the present conditions. Of course, the situation could be saved if there were a strong administrative organization, but unfortunately nothing is done to gain this end and nobody is here who could bring it about. The operating commissions consist of men who have not the slightest idea of mines and of steel works. The work of the central administration is terribly depressing. The engineers are physically and mentally broken down without rights of protection; they are intimidated victims for insults and oppression.

The Russian transportation system is in terrible condition and its reconstruction concerns the government very much without any signs of a recovery. In the railroads there exist gruesome conditions. About 70 per cent of all the rolling stock is out of operation. The railroad stations seem like grave yards in which the corpses of hundreds of defective locomotives and rusted cars stand or lie around, the repair of which seems to be out of the question for quite some time. It is true that Trotzky says in his order No. 1042, addressed to locomotive repair shops that in 1925 Russia will have again sufficient locomotives and cars; but probably he is not convinced of the correctness of his claim. During the year the number of repaired locomotives in the shops increased a little bit compared to the year before, but during the fall, the work dropped off so much that during the winter the number of the preceding year probably cannot be reached. The reason for the falling off is principally that the locomotive sheds and repair shops could not be repaired or maintained for several years because the necessary building material is non-existent. There is no material available for windows, doors or roofs. There is no glass, no roofing paper, no building cement, and no lumber. It is evident that when the hard winter begins nobody can work in the shops which offer no protection against the cold and the destruction of whatever rolling stock that is left goes on without interruption.

Just as sad is the condition with regard to the number and strength of horses. Horse feed can hardly be procured and what few horses are still in existence can scarcely be kept alive. The mines have hardly any horses at all, so that coal can be brought to the cages only with the greatest trouble; and then the orders of the Soviet government often contradict each other in the most unintelligible manner. For instance, great herds of horses and mules have been brought from the Kuban section to the Donetz region but were requisitioned by the soldiers as soon as they arrived.

In the Soviet administration Saint Bureaucratins rules absolutely. The organization of the government works with a tremendous apparatus of officials, the working efficiency of which is inversely proportional to their number. The authorities have been utterly ruined by favoritism and work very slowly and improperly. Important requests after lying around for days in wrong departments reach the right department too late; the solution of the matter requires additional, almost endless time until the much desired answer reaches the applicant. Usually the answer and the whole work is without value because the purpose of the petition of the latter has passed out of existence and the whole affair is no longer pressing. The result is that important affairs are only taken care of by confidential go-betweens who take the letters to the proper parties and are duty bound to get immediate reply.

It is peculiar to the method of administration of the Soviet government that the communists who are in good repute with their party, never seem to stay any length of time in one place and, for that reason, there is an everlasting and depressing change in important positions in the Donetz region, which region needs a cautious, energetic and thoroughly experienced administration. This fact explains the miserable result that today after a year of administration practically nothing has been accomplished in the Donetz region. With all that, the administration is too jumpy and full of contradictions, depending too much upon the moods and whims of the directors who have no technical knowledge. Orders of yesterday are cancelled today to make way for new orders tomorrow. Since there is no definite direction by the central administration, work in the individual sections sags and stops. Furthermore, coöperation is made very difficult, if not impossible, by the utterly unsatisfactory conditions of the postal and transportation service.

The output of the workmen in the Donetz region has fallen off deplorably which can be explained from the fact that most of the workmen don't work but occupy themselves principally with secret sales and by the gain resulting therefrom attempt to bolster up their wholly insufficient wages. The official food situation can not be described. The workmen do not even receive sufficient bread to sustain life. To get a supply of meat and fat is out of the question as long as the Bolsheviks rule. Neither the working man's clothes nor his shoes are sufficient. Many of the workmen are almost wholly naked and have no expectation of ever obtaining a suit of clothes or a pair of shoes; but the chief communists stride around in leather suits and in good shoes. These gentlemen also obtain cloth from which good clothing can be made. On the other hand, the industrial workmen, even if they are communists, walk around in rags and barefoot. The communistic representative, Dr. Levi, said last year in the German Diet that the "Proletariat" nowhere lives as well as in Soviet Russia. But actually the opposite is true; nowhere the workmen face as bad conditions as in Russia. The government imposes compulsory hard labor which is a terrible thing under the present conditions of underfeeding of the men and of their families. With his paltry monthly wages of 6,000 rubles and the usual bonus of 130 per cent, the workmen cannot buy food with the present high prices unless he steals and makes secret sales. All trade lies only in the hands of secret salesmen and the wares are either traded against other wares or else paid for by tremendously high sums of paper money. Thus a very inferior, hardly eatable loaf of bread costs 600 rubels, meat from 1,300 to 2,000 rubles, fat and butter 5,000 to 6,000 rubles a pound, salt 800 rubles a pound, a box of matches 280 rubles, a pound of potatoes 50 rubles, and a glass of milk 250 rubles. The price of clothing is out of sight and a pair of shoes costs 65,000 rubles.

Piece-work which is so often decried by socialism has again been introduced thoroughly in Soviet Russia, because the government has recognized that reconstruction of industry is impossible without it. Important is the observation of what the government does in case of strikes and what its position is towards the unions. A strike is almost impossible in Soviet Russia, because any movement towards obtaining higher wages or better working conditions is considered a counter-revolutionary act and is treated as such; that is, the leaders are imprisoned immediately and as a rule are shot. It is known that the workmen are very much dissatisfied with the government and will be very glad to shake off the unbearable yoke, but the terrible reign of terror keeps them cowed. They are too powerless and apathetic to revolt against the iron rule. Officers for the protection of workmen do not exist, because the unions are led and conducted by communists, receive their directions from the state, and naturally will not allow anything which might displease the Soviet government. One must therefore be careful not to draw comparison between unions in other countries and those in Russia, as the latter have not the least power or possibility to do anything for the welfare of their members.

With the present condition of production and method of administration, the government is, of course, not in position to offer anything to foreign trade and to import goods of which it is very much in need. Only a change of the system can change conditions and can lead Russia to a new and more happy future which would allow trade in industry to enter into valuable economical connection into Russia and to gain a foothold in the Ukraina as it was before the war. But even the most hopeful human being cannot believe that this condition can be brought about in the near future. The chaos is still much too great.

Large Blooming Mill Motor Drive Completed

The General Electric Company Have Completed a 40-Inch Reversing Blooming Mill Drive for Tata Iron and Steel Company, Jamshedpur, India.

THE General Electric Company has recently completed a 40-inch reversing blooming mill motor drive, complete with reversing motor, flywheel motor generator, control and auxiliaries for the plant of the Tata Iron & Steel Co., Jamshedpur, India. This electrical equipment is of the same type as those which have proven so successful in the plants of the Tennessee Coal Iron & R. R. Co., Trumbull Steel Company, Bethlehem Steel Company and other mills.

The reversing motor is of the double unit type, consisting of two shunt wound motors on a common shaft, and is rated 7,000 hp (50° C rise) at 55 to 120 rpm. Power is supplied by a flywheel motor generator, composed of three 2,700 kw (50° C) generators and one 50-ton (45,000 kg) flywheel, all driven by a direct connected induction motor, having a continuous capacity of 5,000 hp (50°) at 375 rpm.

The motors are of very strong construction throughout, so as to withstand the severe shocks to which they will be subjected. The mill end bearing affords a good example of this construction. This bearing is 30 inches in diameter by 70 inches in length and is mounted in a spherical seat on a cast steel pillow block which also supports a lubricated babbitted thrust plate, against which the motor half of the coupling may bear in case of a broken mill spindle. The total weight of this complete pillow block, with its bearing and thrust plate, is approximately 61,000 pounds (27,700 kg) and the bolts which secure the cap to the pillow block, and the pillow block itself to the base weighs approximately 2,400 pounds (1,100 kg).

Only the best material is used throughout and full consideration has been given the effect of the frequent reversals of torque. The following brief description of the construction may be of interest.

The shaft is made of a single forging of high-grade open hearth steel, carefully annealed and finished all over, and having the journals polished. The armature spider of each unit is a single steel casting carrying an extension on which the commutator is pressed and keyed, thus preventing all movement between the commutator and armature, and allowing the armature, less shaft, to be handled as a unit. The laminations which form the magnetic circuit of the armature are of special steel, securely dovetailed to the armature spider by an overfill method of assembly which eliminates any possibility of loosening due to frequent reversals. The laminations are stacked under tremendous pressure and secured by end flanges held by through bolts, which do not pierce the active magnetic material.

The armature windings consist of copper bars, thoroughly insulated with special mica insulation and moulded to exact size before being assembled in the slots, where they are held securely in place by wedges driven into grooves in the teeth. The portion of the windings outside the slots are bound down to the end flanges by sectional binding bands, which prevent displacement due to centrifugal force. This type of band greatly facilitates repairs, as the entire band is readily removed by removing a key between any two sections. A special clamping device is supplied for replacing the band.

The main shunt field, commutating field and compensating field windings are carried on laminated poles bolted to the heavy ribbed section magnet frame. The space between the two magnet frames is enclosed by a sheet steel casing, into which the cooling air is introduced under pressure, which forces it through the armature windings and field coils and out through the commutator ends of the machine. The air, before being taken into the motor, is thoroughly washed and scrubbed and, being discharged into the motor room, tends to build up a slight positive pressure which retards the entrance of mill dirt into the room.

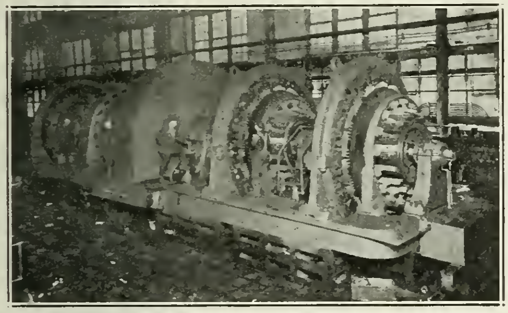


Fig. 1—7,000 hp reversing blooming mill motor consisting of 2 type MCF 22-3,500 hp (50°) 55/120-900 volt units.

The power for driving the reversing mill is obtained from a 4 unit flywheel motor generator, consisting of three 2,700 kw 600 V shunt wound generators. The generator and motor armatures are connected alternately in series through a high capacity solenoid operated air break circuit breaker. Excitation for the shunt fields of the generators and motor is furnished by an induction motor driven exciter.

A slip regulator, connected in the secondary of the induction motor driving the flywheel motor generator, automatically introduces resistance into the secondary circuit, whenever the induction motor load exceeds a pre-determined value, thus causing the induction motor to slow down and allowing the flywheel to carry the load in excess of the regulator setting. Conversely, when the load on the induction motor tends to drop below the regulator setting, resistance is taken out of the secondary circuit and the induction motor input remains practically constant until the flywheel has returned to its maximum speed. In this way, the peaks which are very severe in the dc circuit, are practically eliminated from the ac supply.

Control of the speed and direction of rotation of the main motor is obtained from the single lever master switch in the operator's pulpit. For speeds from 55 rpm forward to 55 rpm reversed, the motor field remains constant at its maximum value, and control is obtained by varying the direction and value of current in the shunt field circuit of the generator. For speeds from 55 rpm to 120 rpm which is the maximum for this particular equipment, control is obtained by varying the motor shunt field current. The control apparatus includes protective devices which prevent abusive handling of the equipment without interfering in the least with the operator as long as the armature currents are not excessive, and as soon as the current drops to a safe value, complete control is returned to the operator.

The following figures which have been obtained under actual rolling conditions on similar equipments are of interest:

The General Electric equipment at the Trumbull Steel Company, driving their 36-inch reversing blooming mill, has rolled one 22 x 60-inch ingot weighing 6,700 pounds down to a 6¾ x 6¾-inch bloom in 11 passes in 45 seconds. Fifty-seven such ingots, having a total weight of 190 short tons, have been rolled to the same final dimensions in one hour.

The 40-inch reversing mill at the Sparrow's Point works of the Bethlehem Steel Company is driven by an electrical equipment very similar to that at the Trumbull Steel Company. This mill has rolled one 23 x 43-inch ingot weighing 16,500 pounds to a slab 9 x 38-inch in 1 minute and 20 seconds, and to a bloom 8 x 8-inch in 2 minutes and 15 seconds. This mill has also rolled 330 tons of 10 x 40-inch slabs in one hour, and 198 tons of 8 x 8-inch blooms in an hour.

These figures tend to show that the modern electrically driven reversing mill is at least on par with the steam driven mill as far as tonnage output is concerned, and when its many advantages, such as economy of power and maintenance, costs, and flexibility and ease of control are considered, the superiority of the electric mill is obvious.

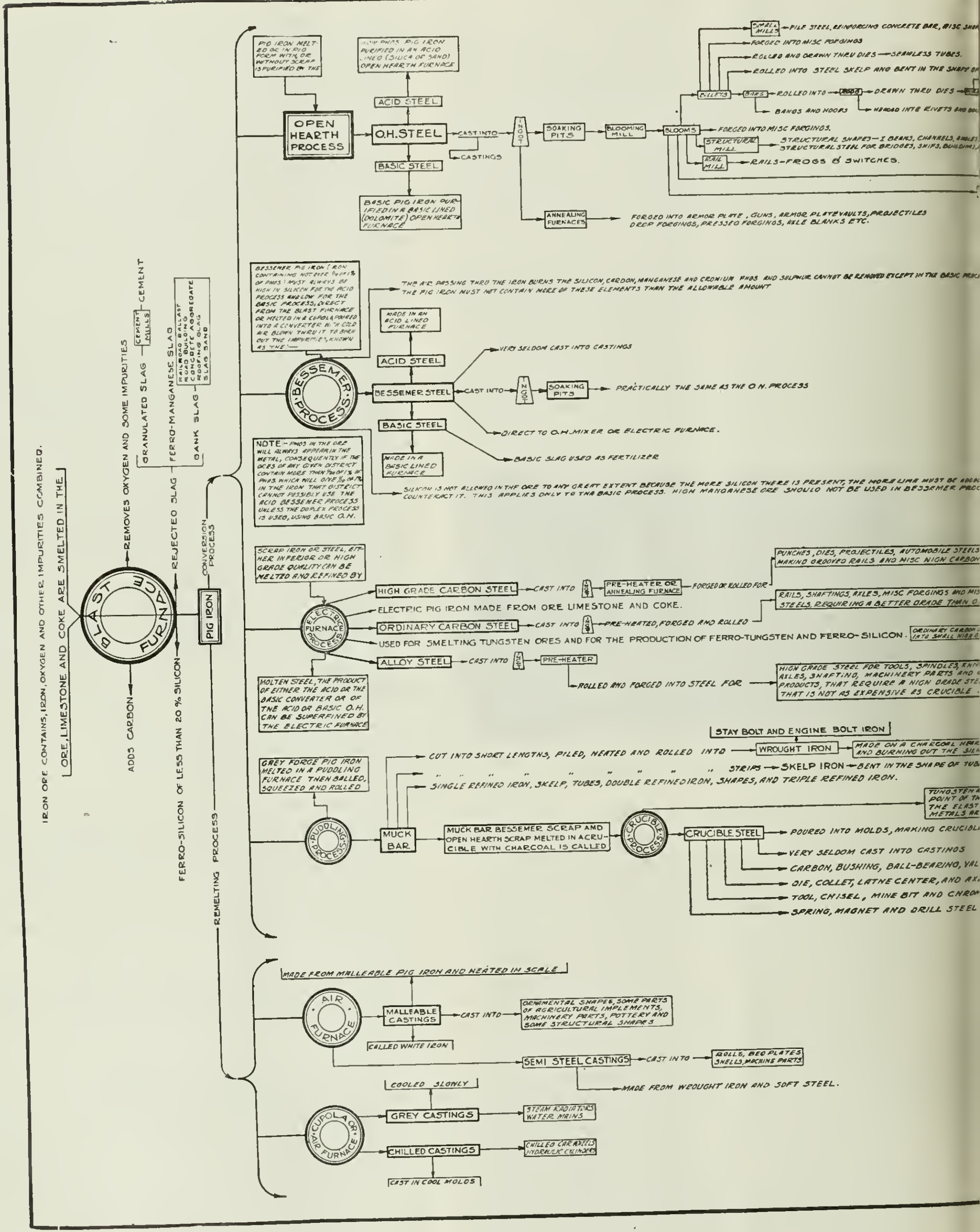
CONVENTION OF AMERICAN DROP FORGE AND DROP FORGE SUPPLY ASSOCIATION.

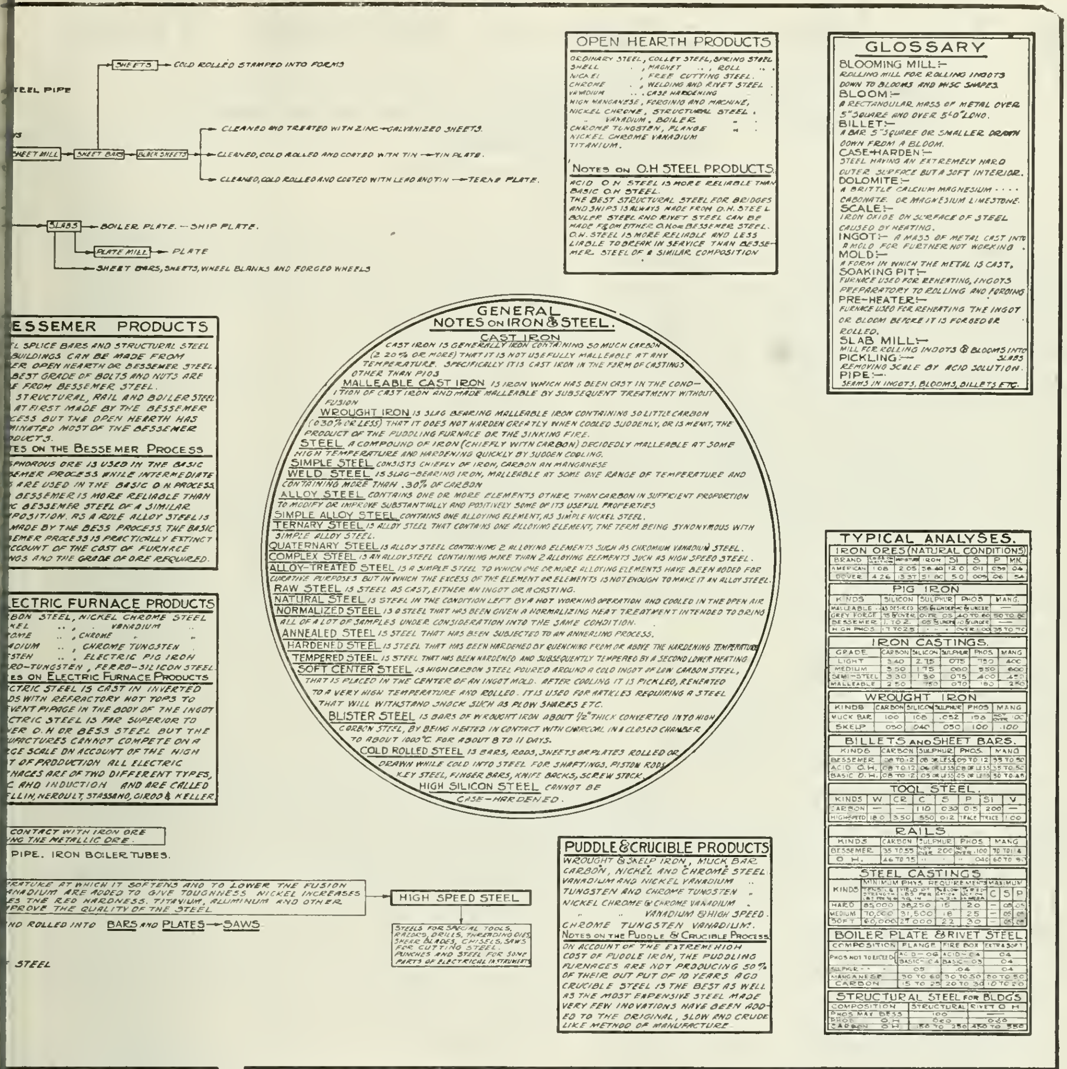
The annual joint convention of the American Drop Forge Association and the Drop Forge Supply Association will be held this year in Chicago, June 22-23-24. The following joint committee in charge of entertainment and general arrangements for the convention has been appointed:

For the American Drop Forge Association: Samuel M. Havens, chairman, Ingalls-Shepard Forging Company, Harvey, Ill.; W. E. Crocombe, Ajar Forge Company, Chicago, Ill.; Thos. P. Octigan, Octigan Drop Forge Company, Chicago, Ill.

For the Drop Forge Supply Association: C. H. Hallgath, chairman, Western Sales Manager, N. & G. Taylor Co., 208 S. LaSalle street, Chicago, Ill.; A. L. Guilford, Manager Chicago Office, Ajax Manufacturing Company, Chicago, Ill.; R. S. LeBarre, General Sales Manager, Alloy Division, Interstate Iron & Steel Co., Chicago, Ill.

The largest attendance in the history of the industry is expected at this convention and plans are now being considered by the committee and the officers of both associations to make this meeting surpass all others in interest, and enjoyment.


IRON ORE CONTAINS, IRON, OXYGEN AND OTHER IMPURITIES COMBINED.
ORE, LIMESTONE AND COKE ARE SMELTED IN THE
BLAST FURNACE
REMOVES OXYGEN AND SOME IMPURITIES
ADDS CARBON
REJECTED SLAG
GRANULATED SLAG
CEMENT MILLS
CEMENT
FERRO-MANGANESE SLAG
BANK SLAG
RAILROAD BALLAST
ROAD BUILDING
CONCRETE AGGREGATE
ROOFING SLAG
SLAG SAND
FERRO-SILICON OF LESS THAN 20 % SILICON
PIG IRON
CONVERSION PROCESS
REMELTING PROCESS
PIG IRON MELTED OR IN PIG FORM WITH OR WITHOUT SCRAP IS PURIFIED BY THE
OPEN HEARTH PROCESS
LOW PHOS PIG IRON PURIFIED IN AN ACID LINED (SILICA OR SAND) OPEN HEARTH FURNACE
ACID STEEL
O.H. STEEL
BASIC STEEL
BASIC PIG IRON PURIFIED IN A BASIC LINED (DOLOMITE) OPEN HEARTH FURNACE
CAST INTO
CASTINGS
INGOT
SOAKING PITS
BLOOMING MILL
BLOOMS
BILLETS
BARS
ROD
SMALL MILLS
PILE STEEL, REINFORCING CONCRETE BAR, MISC SH
FORGED INTO MISC FORGINGS
ROLLED AND DRAWN THRU DIES — SEAMLESS TUBES.
ROLLED INTO STEEL SKELP AND BENT IN THE SHAPE OF
ROLLED INTO
DRAWN THRU DIES
BANDS AND HOOPS
HEADED INTO RIVETS AND BO
FORGED INTO MISC FORGINGS.
STRUCTURAL MILL
STRUCTURAL SHAPES — I BEAMS, CHANNELS, ANGLES
STRUCTURAL STEEL FOR BRIDGES, SHIPS, BUILDINGS
RAIL MILL
RAILS — FROGS & SWITCHES.
ANNEALING FURNACES
FORGED INTO ARMOR PLATE, GUNS, ARMOR PLATE VAULTS, PROJECTILES
DROP FORGINGS, PRESSED FORGINGS, AXLE BLANKS ETC.
BESSEMER PIG IRON (IRON CONTAINING NOT OVER 1/10 OF 1% OF PHOS) MUST ALWAYS BE HIGH IN SILICON FOR THE ACID PROCESS AND LOW FOR THE BASIC PROCESS; DIRECT FROM THE BLAST FURNACE OR MELTED IN A CUPOLA POURED INTO A CONVERTER WITH COLD AIR BLOWN THRU IT TO BURN OUT THE IMPURITIES, KNOWN AS THE —
THE AIR PASSING THRU THE IRON BURNS THE SILICON, CARBON, MANGANESE AND CRONIUM PHOS AND SULPHUR CANNOT BE REMOVED EXCEPT IN THE BASIC PROC
THE PIG IRON MUST NOT CONTAIN MORE OF THESE ELEMENTS THAN THE ALLOWABLE AMOUNT
MADE IN AN ACID LINED FURNACE
ACID STEEL
BESSEMER PROCESS
BESSEMER STEEL
CAST INTO
INGOT
SOAKING PITS
VERY SELDOM CAST INTO CASTINGS
PRACTICALLY THE SAME AS THE O.H. PROCESS
BASIC STEEL
DIRECT TO O.H. MIXER OR ELECTRIC FURNACE.
MADE IN A BASIC LINED FURNACE
BASIC SLAG USED AS FERTILIZER
NOTE — PHOS IN THE ORE WILL ALWAYS APPEAR IN THE METAL, CONSEQUENTLY IF THE ORES OF ANY GIVEN DISTRICT CONTAIN MORE THAN 1/20 OF 1% OF PHOS WHICH WILL GIVE 1/10 OF 1% IN THE IRON THAT DISTRICT CANNOT POSSIBLY USE THE ACID BESSEMER PROCESS UNLESS THE DUPLEX PROCESS IS USED, USING BASIC O.H.
SILICON IS NOT ALLOWED IN THE ORE TO ANY GREAT EXTENT BECAUSE THE MORE SILICON THERE IS PRESENT, THE MORE LIME MUST BE ADDE
COUNTERACT IT. THIS APPLIES ONLY TO THE BASIC PROCESS. HIGH MANGANESE ORE SHOULD NOT BE USED IN BESSEMER PROC
SCRAP IRON OR STEEL, EITHER INFERIOR OR HIGH GRADE QUALITY CAN BE MELTED AND REFINED BY
ELECTRIC FURNACE PROCESS
HIGH GRADE CARBON STEEL
CAST INTO
INGOT
PRE-HEATER OR ANNEALING FURNACE
FORGED OR ROLLED FOR
PUNCHES, DIES, PROJECTILES, AUTOMOBILE STEELS
MAKING GROOVED RAILS AND MISC HIGH CARBON
ELECTRIC PIG IRON MADE FROM ORE LIMESTONE AND COKE.
RAILS, SHAFTINGS, AXLES, MISC FORGINGS AND MIS
STEELS, REQUIRING A BETTER GRADE THAN O
ORDINARY CARBON STEEL
CAST INTO
PRE-HEATED, FORGED AND ROLLED
USED FOR SMELTING TUNGSTEN ORES AND FOR THE PRODUCTION OF FERRO-TUNGSTEN AND FERRO-SILICON.
ORDINARY CARBON
INTO SMALL HIGH G
ALLOY STEEL
CAST INTO
PRE-HEATER
ROLLED AND FORGED INTO STEEL FOR
HIGH GRADE STEEL FOR TOOLS, SPINDLES, KNI
AXLES, SHAFTING, MACHINERY PARTS AND
PRODUCTS, THAT REQUIRE A HIGH GRADE STE
THAT IS NOT AS EXPENSIVE AS CRUCIBLE
MOLTEN STEEL, THE PRODUCT OF EITHER THE ACID OR THE BASIC CONVERTER OR OF THE ACID OR BASIC O.H. CAN BE SUPERFINED BY THE ELECTRIC FURNACE
STAY BOLT AND ENGINE BOLT IRON
CUT INTO SHORT LENGTHS, PILED, HEATED AND ROLLED INTO
WROUGHT IRON
MADE ON A CHARCOAL HEAR
AND BURNING OUT THE SIL
" " " " " " " " " STRIPS
SKELP IRON
BENT IN THE SHAPE OF TUB
SINGLE REFINED IRON, SKELP, TUBES, DOUBLE REFINED IRON, SHAPES, AND TRIPLE REFINED IRON.
GREY FORGE PIG IRON MELTED IN A PUDDLING FURNACE THEN BALLED, SQUEEZED AND ROLLED
PUDDLING PROCESS
MUCK BAR
MUCK BAR BESSEMER SCRAP AND OPEN HEARTH SCRAP MELTED IN A CRUCIBLE WITH CHARCOAL IS CALLED
CRUCIBLE PROCESS
TUNGSTEN
POINT OF TH
THE ELAST
METALS AR
CRUCIBLE STEEL
POURED INTO MOLDS, MAKING CRUCIBL
VERY SELDOM CAST INTO CASTINGS
CARBON, BUSHING, BALL-BEARING, VAL
DIE, COLLET, LATHE CENTER, AND AX
TOOL, CHISEL, MINE BIT AND CHRO
SPRING, MAGNET AND DRILL STEEL
MADE FROM MALLEABLE PIG IRON AND HEATED IN SCALE
AIR FURNACE
MALLEABLE CASTINGS
CAST INTO
ORNAMENTAL SHAPES, SOME PARTS OF AGRICULTURAL IMPLEMENTS, MACHINERY PARTS, POTTERY AND SOME STRUCTURAL SHAPES
CALLED WHITE IRON
SEMI STEEL CASTINGS
CAST INTO
ROLLS, BED PLATES SHELLS, MACHINE PARTS
MADE FROM WROUGHT IRON AND SOFT STEEL.
COOLED SLOWLY
CUPOLA OR AIR FURNACE
GREY CASTINGS
STEAM RADIATORS WATER MAINS
CHILLED CASTINGS
CHILLED CAR WHEELS HYDRAULIC CYLINDERS
CAST IN COOL MOLDS


SHEETS
COLD ROLLED STAMPED INTO FORMS
TEEL PIPE
S
HEET MILL
SHEET BARS
BLACK SHEETS
CLEANED AND TREATED WITH ZINC → GALVANIZED SHEETS.
CLEANED, COLD ROLLED AND COATED WITH TIN → TIN PLATE.
CLEANED, COLD ROLLED AND COATED WITH LEAD AND TIN → TERNE PLATE.
SLABS
BOILER PLATE. — SHIP PLATE.
PLATE MILL
PLATE
SHEET BARS, SHEETS, WHEEL BLANKS AND FORGED WHEELS
CONTACT WITH IRON ORE
ING THE METALLIC ORE.
PIPE. IRON BOILER TUBES.
RATURE AT WHICH IT SOFTENS AND TO LOWER THE FUSION
ANADIUM ARE ADDED TO GIVE TOUGHNESS NICKEL INCREASES
ES THE RED HARDNESS. TITANIUM, ALUMINUM AND OTHER
PROVE THE QUALITY OF THE STEEL
HIGH SPEED STEEL
STEELS FOR SPECIAL TOOLS, RAZORS, DRILLS, THREADING DIES, SHEAR BLADES, CHISELS, SAWS FOR CUTTING STEEL. PUNCHES AND STEEL FOR SOME PARTS OF ELECTRICAL INSTRUMENTS
NO ROLLED INTO BARS AND PLATES → SAWS
STEEL

ESSEMER PRODUCTS

L SPLICE BARS AND STRUCTURAL STEEL BUILDINGS CAN BE MADE FROM ER OPEN HEARTH OR BESSEMER STEEL. BEST GRADE OF BOLTS AND NUTS ARE E FROM BESSEMER STEEL. STRUCTURAL, RAIL AND BOILER STEEL AT FIRST MADE BY THE BESSEMER CESS BUT THE OPEN HEARTH HAS MINATED MOST OF THE BESSEMER DUCTS.

TES ON THE BESSEMER PROCESS

SPHOROUS ORE IS USED IN THE BASIC SEMER PROCESS WHILE INTERMEDIATE S ARE USED IN THE BASIC O H PROCESS BESSEMER IS MORE RELIABLE THAN C BESSEMER STEEL OF A SIMILAR POSITION. AS A RULE ALLOY STEEL IS MADE BY THE BESS PROCESS. THE BASIC EMER PROCESS IS PRACTICALLY EXTINCT CCOUNT OF THE COST OF FURNACE NGS AND THE GRADE OF ORE REQUIRED.

ECTRIC FURNACE PRODUCTS

BON STEEL, NICKEL CHROME STEEL
KEL " , " VANADIUM "
OME " , CHROME " "
DIUM " , CHROME TUNGSTEN "
STEN " , ELECTRIC PIG IRON
RO-TUNGSTEN , FERRO-SILICON STEEL.

ES ON ELECTRIC FURNACE PRODUCTS

CTRIC STEEL IS CAST IN INVERTED DS WITH REFRACTORY HOT TOPS TO VENT PIPAGE IN THE BODY OF THE INGOT CTRIC STEEL IS FAR SUPERIOR TO ER O.H OR BESS STEEL BUT THE UFACTURES CANNOT COMPETE ON A GE SCALE ON ACCOUNT OF THE HIGH T OF PRODUCTION ALL ELECTRIC NACES ARE OF TWO DIFFERENT TYPES, C AND INDUCTION AND ARE CALLED LLIN, HEROULT, STASSANO, GIROD & KELLER

OPEN HEARTH PRODUCTS

ORDINARY STEEL, COLLET STEEL, SPRING STEEL
SHELL " , MAGNET " , ROLL "
NICKEL " , FREE CUTTING STEEL.
CHROME " , WELDING AND RIVET STEEL "
VANADIUM " , CASE HARDENING "
HIGH MANGANESE, FORGING AND MACHINE,
NICKEL CHROME, STRUCTURAL STEEL.
" VANADIUM, BOILER " "
CHROME TUNGSTEN, FLANGE " "
NICKEL CHROME VANADIUM
TITANIUM.

NOTES ON O.H STEEL PRODUCTS.

ACID O H STEEL IS MORE RELIABLE THAN BASIC O.H STEEL.
THE BEST STRUCTURAL STEEL FOR BRIDGES AND SHIPS IS ALWAYS MADE FROM O.H. STEEL BOILER STEEL AND RIVET STEEL CAN BE MADE FROM EITHER O.H or BESSEMER STEEL. O.H. STEEL IS MORE RELIABLE AND LESS LIABLE TO BREAK IN SERVICE THAN BESSEMER STEEL OF A SIMILAR COMPOSITION

GENERAL NOTES ON IRON & STEEL.

CAST IRON

CAST IRON IS GENERALLY IRON CONTAINING SO MUCH CARBON (2 20% OR MORE) THAT IT IS NOT USEFULLY MALLEABLE AT ANY TEMPERATURE. SPECIFICALLY IT IS CAST IRON IN THE FORM OF CASTINGS OTHER THAN PIGS

MALLEABLE CAST IRON IS IRON WHICH HAS BEEN CAST IN THE CONDITION OF CAST IRON AND MADE MALLEABLE BY SUBSEQUENT TREATMENT WITHOUT FUSION

WROUGHT IRON IS SLAG BEARING MALLEABLE IRON CONTAINING SO LITTLE CARBON (0 30% OR LESS) THAT IT DOES NOT HARDEN GREATLY WHEN COOLED SUDDENLY, OR IS MENT, THE PRODUCT OF THE PUDDLING FURNACE OR THE SINKING FIRE.

STEEL A COMPOUND OF IRON (CHIEFLY WITH CARBON) DECIDEDLY MALLEABLE AT SOME HIGH TEMPERATURE AND HARDENING QUICKLY BY SUDDEN COOLING.

SIMPLE STEEL CONSISTS CHIEFLY OF IRON, CARBON AN MANGANESE

WELD STEEL IS SLAG-BEARING IRON, MALLEABLE AT SOME ONE RANGE OF TEMPERATURE AND CONTAINING MORE THAN .30% OF CARBON

ALLOY STEEL CONTAINS ONE OR MORE ELEMENTS OTHER THAN CARBON IN SUFFICIENT PROPORTION TO MODIFY OR IMPROVE SUBSTANTIALLY AND POSITIVELY SOME OF ITS USEFUL PROPERTIES

SIMPLE ALLOY STEEL CONTAINS ONE ALLOYING ELEMENT, AS SIMPLE NICKEL STEEL.

TERNARY STEEL IS ALLOY STEEL THAT CONTAINS ONE ALLOYING ELEMENT, THE TERM BEING SYNONYMOUS WITH SIMPLE ALLOY STEEL.

QUATERNARY STEEL IS ALLOY STEEL CONTAINING 2 ALLOYING ELEMENTS SUCH AS CHROMIUM VANADIUM STEEL.

COMPLEX STEEL IS AN ALLOY STEEL CONTAINING MORE THAN 2 ALLOYING ELEMENTS SUCH AS HIGH SPEED STEEL.

ALLOY-TREATED STEEL IS A SIMPLE STEEL TO WHICH ONE OR MORE ALLOYING ELEMENTS HAVE BEEN ADDED FOR CURATIVE PURPOSES BUT IN WHICH THE EXCESS OF THE ELEMENT OR ELEMENTS IS NOT ENOUGH TO MAKE IT AN ALLOY STEEL.

RAW STEEL IS STEEL AS CAST, EITHER AN INGOT OR A CASTING.

NATURAL STEEL IS STEEL IN THE CONDITION LEFT BY A HOT WORKING OPERATION AND COOLED IN THE OPEN AIR

NORMALIZED STEEL IS A STEEL THAT HAS BEEN GIVEN A NORMALIZING HEAT TREATMENT INTENDED TO BRING ALL OF A LOT OF SAMPLES UNDER CONSIDERATION INTO THE SAME CONDITION.

ANNEALED STEEL IS STEEL THAT HAS BEEN SUBJECTED TO AN ANNEALING PROCESS.

HARDENED STEEL IS STEEL THAT HAS BEEN HARDENED BY QUENCHING FROM OR ABOVE THE HARDENING TEMPERATURE

TEMPERED STEEL IS STEEL THAT HAS BEEN HARDENED AND SUBSEQUENTLY TEMPERED BY A SECOND LOWER HEATING

SOFT CENTER STEEL IS HIGH CARBON STEEL POURED AROUND A COLD INGOT OF LOW CARBON STEEL, THAT IS PLACED IN THE CENTER OF AN INGOT MOLD. AFTER COOLING IT IS PICKLED, REHEATED TO A VERY HIGH TEMPERATURE AND ROLLED. IT IS USED FOR ARTICLES REQUIRING A STEEL THAT WILL WITHSTAND SHOCK SUCH AS PLOW SHARES ETC.

BLISTER STEEL IS BARS OF WROUGHT IRON ABOUT 1/2" THICK CONVERTED INTO HIGH CARBON STEEL, BY BEING HEATED IN CONTACT WITH CHARCOAL IN A CLOSED CHAMBER TO ABOUT 1000°C. FOR ABOUT 8 TO 11 DAYS.

COLD ROLLED STEEL IS BARS, RODS, SHEETS OR PLATES ROLLED OR DRAWN WHILE COLD INTO STEEL FOR SHAFTINGS. PISTON RODS KEY STEEL, FINGER BARS, KNIFE BACKS, SCREW STOCK.

HIGH SILICON STEEL CANNOT BE CASE-HARDENED.

PUDDLE & CRUCIBLE PRODUCTS

WROUGHT & SKELP IRON, MUCK BAR
CARBON, NICKEL AND CHROME STEEL
VANADIUM AND NICKEL VANADIUM "
TUNGSTEN AND CHROME TUNGSTEN "
NICKEL CHROME & CHROME VANADIUM "
" " VANADIUM & HIGH SPEED.
CHROME TUNGSTEN VANADIUM.

NOTES ON THE PUDDLE & CRUCIBLE PROCESS

ON ACCOUNT OF THE EXTREME HIGH COST OF PUDDLE IRON, THE PUDDLING FURNACES ARE NOT PRODUCING 50% OF THEIR OUT PUT OF 10 YEARS AGO CRUCIBLE STEEL IS THE BEST AS WELL AS THE MOST EXPENSIVE STEEL MADE VERY FEW INOVATIONS HAVE BEEN ADDED TO THE ORIGINAL, SLOW AND CRUDE LIKE METHOD OF MANUFACTURE

GLOSSARY

BLOOMING MILL:—
ROLLING MILL FOR ROLLING INGOTS DOWN TO BLOOMS AND MISC SHAPES.

BLOOM:—
A RECTANGULAR MASS OF METAL OVER 5" SQUARE AND OVER 5'-0" LONG.

BILLET:—
A BAR 5" SQUARE OR SMALLER DRAWN DOWN FROM A BLOOM.

CASE-HARDEN:—
STEEL HAVING AN EXTREMELY HARD OUTER SURFACE BUT A SOFT INTERIOR.

DOLOMITE:—
A BRITTLE CALCIUM MAGNESIUM .... CABONATE. OR MAGNESIUM LIMESTONE.

SCALE:—
IRON OXIDE ON SURFACE OF STEEL CAUSED BY HEATING.

INGOT:— A MASS OF METAL CAST INTO A MOLD FOR FURTHER HOT WORKING.

MOLD:—
A FORM IN WHICH THE METAL IS CAST.

SOAKING PIT:—
FURNACE USED FOR REHEATING, INGOTS PREPARATORY TO ROLLING AND FORGING

PRE-HEATER:—
FURNACE USED FOR REHEATING THE INGOT OR BLOOM BEFORE IT IS FORGED OR ROLLED.

SLAB MILL:—
MILL FOR ROLLING INGOTS & BLOOMS INTO SLABS

PICKLING:—
REMOVING SCALE BY ACID SOLUTION.

PIPE:—
SEAMS IN INGOTS, BLOOMS, BILLETS ETC.

TYPICAL ANALYSES.

IRON ORES (NATURAL CONDITIONS)

BRAND	LOSS ON IGNITION	MOISTURE	IRON	SI	S	P	MN.
AMERICAN	1 08	2 05	56 40	12 0	011	039	04
DOVER	4 26	13 37	51 80	5 0	005	06	54

PIG IRON

KINDS	SILICON	SULPHUR	PHOS	MANG.
MALLEABLE	AS DESIRED	05 & UNDER	20 & UNDER	—
GREY FORGE	15 & OVER	OVER 05	40 TO 60	50 TO 80
BESSEMER	1. TO 2.	05 & UNDER	10 & UNDER	—
HIGH PHOS	1.7 TO 2.5	" " "	OVER 1 00	35 TO 70

IRON CASTINGS.

GRADE	CARBON	SILICON	SULPHUR	PHOS.	MANG
LIGHT	3 40	2.75	075	750	400
MEDIUM	3 50	1 75	080	550	600
SEMI-STEEL	3 30	1 30	075	400	450
MALLEABLE	2 50	750	070	180	250

WROUGHT IRON

KINDS	CARBON	SILICON	SULPHUR	PHOS	MANG
MUCK BAR	100	108	.052	198	NOT OVER 100
SKELP	050	040	050	100	.100

BILLETS AND SHEET BARS.

KINDS	CARBON	SULPHUR	PHOS.	MANG
BESSEMER	08 TO 12	08 OR LESS	05 TO 12	35 TO 50
ACID O.H.	08 TO 12	06 OR LESS	06 OR LESS	35 TO 50
BASIC O.H.	08 TO 12	05 OR LESS	05 OR LESS	30 TO 48

TOOL STEEL.

KINDS	W	CR	C	S	P	SI	V
CARBON	—	—	110	030	015	200	—
HIGH SPEED	18 0	3 50	550	012	TRACE	TRACE	1 00

RAILS

KINDS	CARBON	SULPHUR	PHOS	MANG
BESSEMER	35 TO 55	NOT OVER 200	NOT OVER .100	70 TO 1 4
O H.	46 TO 75	" "	" 040	60 TO 90

STEEL CASTINGS

KINDS	MINIMUM PHYS. REQUIREMENTS				MAXIMUM		
	TENSILE STRENGTH LBS PER SQ IN	YIELD PT LBS PER SQ IN	% ELONGATION IN 2 IN	% RED. OF AREA	C	S	P
HARD	85,000	38,250	15	20	—	05	05
MEDIUM	70,000	31,500	18	25	—	05	05
SOFT	60,000	27 000	22	30	—	05	05

BOILER PLATE & RIVET STEEL

COMPOSITION	FLANGE	FIRE BOX	EXTRA SOFT
PHOS NOT TO EXCEED	ACID — 06 BASIC — 04	ACID — 04 BASIC — 03	04 04
SULPHUR " "	05	.04	04
MANGANESE	30 TO 60	30 TO 50	30 TO 50
CARBON	15 TO 25	20 TO 30	10 TO 20

STRUCTURAL STEEL FOR BLDGS

COMPOSITION	STRUCTURAL	RIVET O H
PHOS MAX BESS	100	—
PHOS O.H	060	030
CARBON O H	150 TO 250	450 TO 550

POLA & AIR FURNACE PRODUCTS

GREY CASTINGS
CHILLED CASTINGS
MALLEABLE CASTINGS
SEMI-STEEL CASTINGS
CAST-IRON CASTINGS

:— FOUNDRY PIG IRON MELTED IN A CUPOLA CAST INTO MOLDS MAKE IRON CASTINGS IRON MELTED IN A CUPOLA OR AIR RNACE CAST INTO MOLDS OF EITHER KED SAND (OVEN DRIED) OR GREEN SAND ST UNDRIED) OR SOMETIMES OF IRON ERED WITH A REFRACTORY COATING, TO OTECT IT FROM BEING MELTED OR R-HEATED, BY THE MOLTEN CAST IRON, KE GREY AND CHILLED CASTINGS

DEVELOPMENT OF IRON ORE INTO IRON AND STEEL

By S. C. DICKERHOFF, JR.

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NOTE: Copies of this chart may be secured from the BLAST FURNACE AND STEEL PLANT at the following prices:

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30" x 50"—Blue Prints ....$2.00 each, $20.00 per doz.

On The Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesmann Oblique Rolling Process.

By DR. ING. KARL GRUBER IN RHEYDT.

PART III

6. *Interdependence of Formation of Hollow and Torsional Angle.* We now propose to deal with the conditions which develop when the front end of the ingot is inserted into the rolls. The clearance of the rolls is to be such that the solid ingot of 160 mm diameter is rolled down gradually to the small diameter of 136 mm, i.e., down to 1.85 d_0. On the further assumption that the inclination of the side of the working taper of the rolls amounts to 1:15, a length of ingot taper of 180 mm is obtained which is to be divided up in six equal parts (Fig. 14). Now we determine for each of the sections 1 to 6 the torsional angle in degrees according to equation No. 8, using the figures given in Fig. 14 for this purpose.

$$\delta = \frac{D \times \frac{d_0 - d_1}{d_1} - D_0 \times \frac{d_0 - d_1}{d_0}}{D + D_0} \times \frac{360}{\pi \tan \beta \tan \delta}$$

With $\beta = 5°$ and $\tan \delta = 1/15$, the second element becomes

$$\frac{360}{\pi \times 0.0875 \times 1/15} = \frac{360}{0.01833} = 19{,}640.$$

Now for the first cross section we obtain:

$$\delta_1 = \frac{340 \times 4/156 - 336 \times 4/160}{340 + 336} \times 19{,}640$$

$$\delta_1 = \frac{0.318}{676} \times 19{,}640 = 9.24°$$

Similarly, for the other cross sections the following is obtained:

$$\delta_2 = \frac{344 \times 8/152 - 336 \times 8/160}{344 + 336} \times 19{,}640 = 37.54°$$

$$\delta_3 = \frac{348 \times 12/148 - 336 \times 12/160}{348 + 336} \times 19{,}640 = 86.14°$$

$$\delta_4 = \frac{352 \times 16/144 - 336 \times 16/160}{352 + 336} \times 19{,}400 = 157.00°$$

$$\delta_4 = \frac{356 \times 20/140 - 336 \times 20/160}{356 + 336} \times 19{,}640 = 157.00°$$

$$\delta_0 = \frac{360 \times 24/136 - 336 \times 24/160}{360 + 336} \times 19{,}640 = 370.50°$$

The torsional angles have been plotted in Fig. 15 as ordinates and the resulting curve shows in which rapid way they are growing. From this it may be taken that the formation of the hollow proceeds at a rapid rate as well.

At the beginning, from zero up to 1, the curve is rising but very hesitatingly and at the point 1 probably only the beginning of hollowing action would be noticeable.

The formation of a hollow by a torsioning of the whole cross section is hardly feasible, more especially so as the forces at disposal would not suffice for the purpose. *It appears to be correct, however, that a torsioning of the material on the outside surface takes place, as per calculation, and that the particles of the material in the interior* follow the outer ones in this movement causing the inner *material to be drawn to the surface, owing to its cohesive properties.*

Using this theory for oblique rolling process and considering the various cross sections 0 to 6 after having determined the various torsional angles of the outside fiber, the formation of the hollow can be explained in the way shown in Fig. 17.

At cross section 0 the ingot has just been gripped by the rolls and the radial rods are straight. At cross section 1 a torsioning of the outside fiber $\delta_1 = 9° 24''$ *has already taken place and the radial rod is bent accordingly, so that a hollow must gradually form in the interior since a stretching of the radial rod cannot be assumed. This torsioning is accompanied by a shifting of the fiber in a longitudinal direction causing each radial rod not only to be bent in the plane of the cross section but to be spirally rotated from out of this plane. The radial rods follow the outer circumference in increasing degree when the action proceeds from cross sections 3 to 6, respectively, in accordance with the increase of the torsional angle.* It is unfortunate that experiments cannot be carried out at the present time in order to obtain definite information on the fiber formation; they could be carried through in a way similar to that mentioned in discussing the standard rolling process. Still, there is not much room for doubting that the hollowing of the material is to be explained in the way shown.

The next Fig. 18 shows a radial rod while passing through the cross sections 1 to 6. It will be noticed that the inner ends of the radial rod form a spiral.

If now the torsional angles at the various cross sections are coördinated to the corresponding radii of the hollow, it is possible, for working out the inside width d_1 when the outside diameter equals d_a, to set up the empirical formula:

$$d_a = \frac{d_1}{100} \sqrt{\delta + 0.05\,\delta^2} \qquad (18)$$

Table 2 has been worked out by using this formula, as well as Fig. 18.

Table 2—Torsional Angle When Inserting the Ingot.

Cross Section No.	Torsional Angle Deg.	da/di	da mm	d_1 mm
1	9.24	0.037	156	5.8
2	37.54	0.104	152	15.8
3	86.14	0.214	148	31.7
4	157.00	0.372	144	53.6
5	251.46	0.584	140	81.8
6	370.50	0.85	136	116

In drawing Fig. 14 the valves of the above table have been made use of, and the inside shape of the hollow shown may be taken as a faithful reproduction of what

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[*] Stahl & Eisen, July 1882, page 283-93; February 1883, page 121-22.

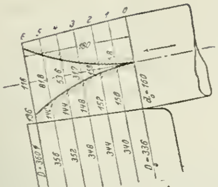
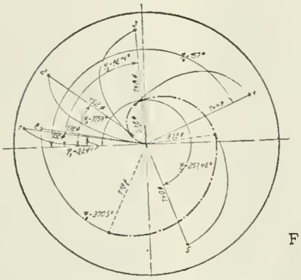


Fig. 14



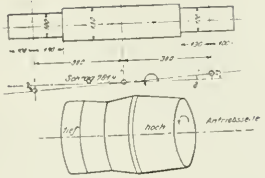


Fig. 30- Top Roll for 360 Mm. Mill.

Fig. 18- Hollow between sections 1 to 6.

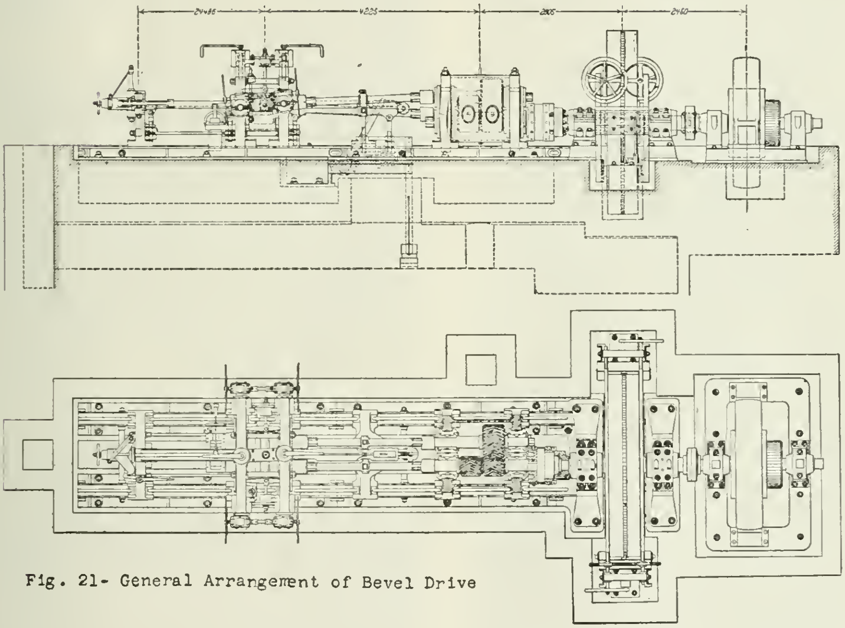
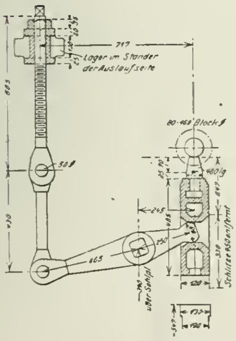
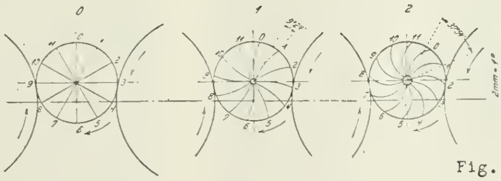


Fig. 21- General Arrangement of Bevel Drive





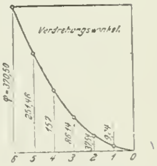


Fig. 15- Torsional Angle

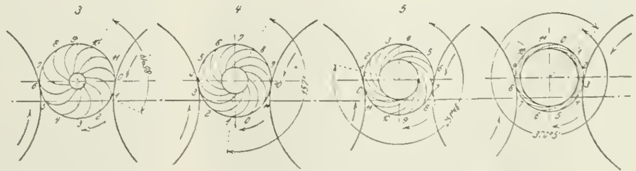


Fig. 25- Lower Grooves between Rolls.

Fig. 17- Formation of Hollow in Mill.

it actually looks like. In this connection special attention should be drawn to the fact that the Stiefel rolling mill, dealt with later on, which is used for making thin walled copper tubes is using torsional angles δ of about 300 degrees. It may therefore be taken that the small thickness of wall obtained in our calculations for 370.5 degrees is not very far from the truth.

In the case of iron tubes, however, the greater thicknesses of wall have to be considered. For instance: If the solid ingot of 160 mm diameter is to be rolled into a hollow bloom with a $d_a = 160$ mm and a $d_i = 110$ mm with an annular cross section of 10,600 sq mm, then this cross section has to be provided at the ingot taper. This happens to be the case very closely at cross section No. 5 (Fig. 14). The rolls have to be adjusted in such a way that the diameter is reduced from 160 to 140 mm.

As soon as the end of the ingot, i.e. cross section No. 6 has reached the rolls, the last phase of the rolling process begins. *The hollow obtained thus far is retained and the smaller inner diameters have now to be forced over the mandrel. The feeding movement is retarded considerably, and the power required which up to the present had been relatively small, increases very appreciably.*

The heavy increase of power forms one of the disadvantages of the oblique rolling mill.

The brothers Mannesmann in the course of their experiments experienced considerable difficulties through this rise in the power requirements towards the end of the rolling process. It had been ascertained that for producing 1 inch or 2 inch tubes, about 1700 or 2000 hp were necessary which, through using a large, high speed flywheel which was wire bound, could be provided. The power required became much less, as soon as the attempt to obtain thin walled iron tubes was dropped and the oblique rolling process was used for the clogging mill only. There is, however, in spite of this a very large increase in the power required towards the end of the rolling process as the hollow is but imperfectly produced so that the material has to be forced over the mandrel.

It was noticed that the power required increased very rapidly towards the end and it therefore appears to be advisable to provide and utilize as heavy flywheels as possible in order to obtain a more evened up load. In the case of electric drive, compound wound motors are used which are capable of carrying a momentary overload of 150 per cent. The rolling process proper takes only about 20 seconds and the additional 16 seconds are required in order to speed up the flywheel to its usual speed which has fallen off owing to the output of power. In order to reduce ingots of up to 160 mm diameter at the big end to a thickness of wall of from about 25 to 30 mm a compound wound motor developing 360 hp, and of the overload capacity stated in conjunction with a 30 ton flywheel running at 150 rpm will be sufficient. Motor and flywheel drop after 20 seconds from 150 to 128 rpm, but after another 16 seconds the original speed has been recovered, provided the voltage can be kept approximately constant during the rolling period.

At present the large rolling mills are fitted with 2000 hp motors and a 40 to 50 ton flywheel while the speed amounts to 100 rpm.

7. *Design of the Rolling Mill*—The bevel drive which was used in the early designs and which is shown in the paper of Prof. Reuleaux caused difficulties and was abandoned later on. The designers of the Mannesmann works have succeeded in developing a design which is still used everywhere. The arrangement is shown in Fig. 21. The main shaft drives a spindle housing which through gearing sets the working rolls into motion, by means of long coupling shafts. This arrangement allows more, especially by using the long coupling shafts, to provide a guide through between the latter which is used for inserting the ingot into the rolls. The wobblers which also during the first few years caused considerable difficulties are now designed on the same lines as in standard rolling mills.

The roll housings are supported by standard bottom plates. Horizontal guides are provided for the bearings of the rolls containing liners with ball shape bearing surfaces through which any required adjustment of the rolls at the front as well as at the rear end becomes possible. The top roll guide, arranged on top in the center, has also a liner provided. The bearings of the three rolls mentioned above are adjustable and by means of springs the liners are pressed against the adjusting screw thus insuring good contact in the bearings. The sliding bar below the top roll moves in a guide.

The leading-in trough has a vertical adjustment of 70 mm and takes billets of from 80 to 160 mm diameter. The billet is moved in the trough by 1,140 mm by means of a ram. If a load of 200 kg including weight of ram has to be shifted in the trough and a counterweight of 110 kg must be lifted the requisite water pressure in the hydraulic cylinder will be 17 to 18 *at*. As the working pressure amounts to from 50 to 100 *at* the billet can therefore be forced into the rolls until the latter have gripped it. The lever must move in the centre slot of the guide because the bearings of the coupling spindles extend to within so short a distance of the guide that the latter cannot be encircled. The coupling spindles are 3,000 mm long and are supported in the middle by bearings of 150 mm diameter, 140 mm long.

In the larger 550 mm rolling mill the coupling spindles are 3,620 mm long and have a diameter of 250 mm. The bearings of the coupling spindles and the supports of the guide troughs are arranged symmetrically at a distance of 2,300 mm from the coupling spindle ends. The two housings thus take the screwed guide spindles, the supports of the bearings and the hydraulic cylinder. The fulcrum of the push-in lever which latter may now move freely and can have a forked top end is supported by a bridge between the two housings.

When the thickness of the block increases from 140 to 450 mm, the guide trough has to be lowered by 220 mm. In the case of tapering ingots the guide trough must be adjusted to an angle so that the orientation of the ingot centre line is perfectly horizontal and falls between the rolls. The largest ingot has a diameter of 450 to 430 mm, a length of 1,200 mm and a weight of 1,400 kg; the weight of the ram which can be extended in this design is 148 kg. The frictional resistance of the two is thus about 150 kg. To this the counterweight of 160 kg has to be added. The force at the point where the plunger acts becomes therefore: $4.3\ (500 + 160) = 2{,}840$ kg. To overcome this a water pressure of 23 *at* has to be used. with a plunger of 140 mm diameter. As the usual water pressure is 50 to 100 *at*, it is seen that there is plenty of margin to effect the pressing-in.

The ram is hollow and takes the extension which is fixed by means of feather or screw. After this has been arranged for, an ingot of 1,000 mm length can be pushed into the rolls.

The oblique position of the coupling spindles (see Fig. 24) in relation to the centre lines of the pinions is found as:

$$\tan \beta_1 = \frac{291^2 + 140^2}{3620} = \frac{323}{3620} = \frac{1}{11.2}$$

The coupling bushes on the rolls will not be much included; on the pinions the inclination is more marked.

Fig. 25 shows an arrangement for guiding the ingot in a rolling mill of 360 mm diameter of rolls. The guide carriage is made of cast iron, has a guide bar and travels between the two roll housings being made to fit closely. A square shaft of 75 mm thickness is supported by two bearings of 75 mm diameter arranged in the housings. To the square shaft two levers are fixed at a distance of 450 mm between centre lines, one being a double armed and the other a short, single armed one. The carriage can only be lowered 40 mm.

In the 550-mm rolling mill the guide carriage is raised and lowered by means of two screws in conjunction with the two worm wheels and a worm which is arranged in the centre. The adjustable hub is mounted on the shaft, outside of the roll housing, and has 6 radially disposed holes for inserting the lever rod.

As the ingot is passed through the rolls in a plane which, in the smaller rolling mill is 40 mm and in the larger one 50 mm higher than the centre plane, this bottom guide is of no great importance and acts as a safety device only.

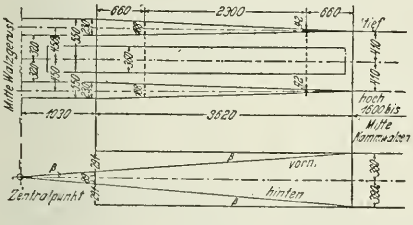


Fig. 24

While the rolling process goes on the hollow bloom revolves on the mandrel the latter being supported at one end by the mandrel thrust bearing and at the other by the hollow bloom itself. After the rolling process is finished, the hollow bloom as well as the mandrel drop on to the discharge trough from which the former can be withdrawn after the mandrel thrust bearing has been opened. In the large rolling mills the guides for the blooms have rollers provided and are also adjustable in a vertical direction.

At the start of the rolling process, the mandrel rests on one end, at the thrust bearing only, and its front end has to be supported until it is gripped by the hollow bloom. This support is supplied by the centering device for the mandrel shown in Fig. 28, which by means of a foot lever keeps the mandrel in the proper position until it has entered into the hollow of the bloom. As soon as the mandrel rod has thus assumed a fixed position, the centering device is disengaged.

A mandrel thrust bearing for a 360-mm rolling mill consists in the main of a swivel bearing which can be clamped in the closed position through a stirrup. This swivel bearing contains a roller thrust bearing for the pinion shaft. The latter has in its front part a die plate with a square recessed opening for the support of the mandrel. When the mandrel rotates, the pinion shaft rotates as well and during rolling runs in the collar thrust bearing. The resistance of the mandrel in the rolling mill is reduced when the mandrel is able to rotate.

The collar thrust bearing can be shifted lengthwise by means of an adjusting screw in order to set the mandrel properly.

The method of operation at the mandrel thrust bearing is as follows:

The mandrel is taken from the trough and after the bearing has been closed is inserted into the die plate. Then by means of the hand wheel the collar thrust bearing is fed forward until the mandrel has assumed the proper position. On the rolling process being finished, the hollow bloom which rests on the mandrel can be removed after the stirrup has been opened. If now a new mandrel of equal length is inserted, the mandrel thrust bearing can again be closed when the centering device for the mandrel will hold the latter up, between the centres of the rolls, until the mandrel has entered a new hollow bloom.

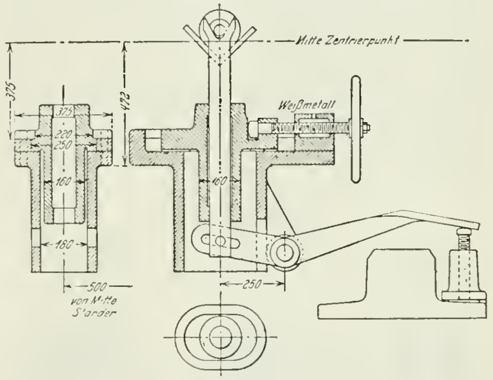


Fig. 28

The mandrel thrust bearings of the 550-mm rolling mills have a hydraulic device for adjusting the collar thrust bearing.

The top roll is arranged over the two side rolls and in this way the top part of the pass is closed (see Fig. 6). The strain on the top roll amounts to 1/3 of the rolling pressure between the main rolls. The direction of rotation is the same as that of the main rolls. The top roll (Fig. 30) is arranged obliquely in a horizontal plane which is disposed 145 to 185 mm over the center point of the rolling mill in such a way that the movement of its circumference is adapted to the helical movement of the hollow bloom.

$$\tan\delta_1 = 23 : 380 = 0.0606 \text{ or } \delta_1 = 3.5°.$$

Experience has shown that s_x can be reduced to about one-half owing to the friction between rolls and specimen and the resistance of the mandrel, and $\delta = 3.5°$ is therefore a suitable value for the degree of obliquity of the top roll. At the same time the degree of obliquity of the top roll as compared with that of the main rolls is so adjusted that the proper clearance between the rolls as well as that in the bearings is obtained.

(To be continued in June Issue)

Electric Furnaces for Making Steel

Classification of Electric Steel Making Furnaces—General Features and Advantages of the Arc Furnace and the Resistance Furnace—Operating Features of Electric Furnaces.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART III

IN this type of furnace each arc is maintained between one electrode and the material to be melted, and the arcs are operated in series of two. The electrical connections of furnaces of this class are shown diagramatically in Fig. 12. Each electric current that is employed enters the furnace by one electrode, passes through an arc, then through the contents of the furnace, then through another arc and finally leaves the furnace by a second electrode. Compared with the Independent Arc Furnaces it will be seen that the material to be melted is heated more rapidly because it forms one pole of each electric arc, and also, to some extent, because it forms the path of the electric current between the two arcs of each series. On the other hand this type of furnace cannot be operated empty, as some conducting material is needed to carry the current. The series feature also causes a certain difficulty in starting the arcs, because both of the electrodes concerned must make contact with the charge before either of the two arcs can be started, and the failure of the one arc, in a single-phase furnace, serves to extinguish the other arc of the pair.

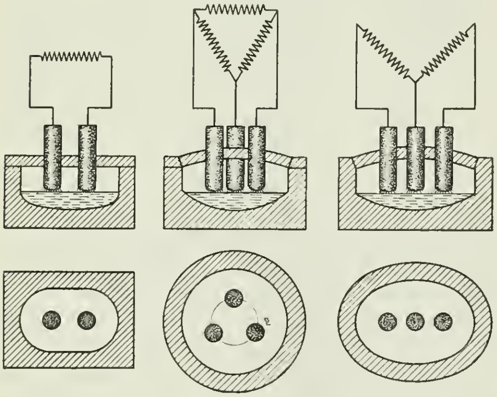


Fig. 12—Heroult Single-phase. Vom Baur Two-phase. Heroult Three-phase. Ludlum Three-phase.

The outstanding example of this type is the Heroult furnace which is built in single-phase and three-phase varieties, but the Ludlum furnace, using three-phase current and the Vom Baur furnace, using two-phase current, are also in the series-arc class.

Heroult Furnace.

The furnace patented by the late Paul Heroult in 1900, has become the most widely used electric furnace for melting and refining steel. While there are many differences in construction between different varieties of this furnace, the points that are common to all may be summarized as follows:

1. The Heroult furnace resembles an open hearth furnace in general construction except that there are no gas or air ports or regenerative chambers and that the heating is effected by means of electric arcs. The furnace may be stationary but is usually made tilting so as to pour the molten steel and for the removal of slag.

2. The electric current is led into and out of the furnace by vertical electrodes of carbon or graphite which pass through the roof of the furnaces. Short electric arcs are maintained between the lower ends of these electrodes and the contents of the furnace.

3. No electrical connection is made to the hearth of the furnace and in consequence the arcs are operated electrically in series of two; that is to say, each electric circuit contains two arcs.

4. The furnace may be supplied with single-phase current, in which case it would have two electrodes, but the great majority use three-phase current and have three electrodes. Furnaces have been designed with four electrodes using two-phase current, and with six electrodes using three-phase current, but no furnaces have been built with more than three electrodes.

5. Electric power is supplied to the furnace at about one hundred volts, being stepped down to this voltage by single-phase or poly-phase service transformers. The transformers should have a moderate amount of inductive regulation in order to control to some extent the violent surgings of current during the melting period.

6. The supply of power to the furnace is controlled by raising and lowering the electrodes. In a single-phase furnace it is necessary to observe the voltage between each electrode and the furnace hearth in order that the power may be divided equally between the two arcs, but in a three-phase furnace the ammeter reading can be used for the regulation of each electrode. The electrodes can be regulated by hand but automatic regulators are generally employed.

7. The electrodes are supported by mechanism attached to the furnace shell so that the furnace can be tilted without affecting the height of the electrodes above the charge.

The construction of the Heroult furnace can be seen from the following illustration:

In Fig. 13 is shown the construction of a Heroult furnace of small size such as would be suitable for a

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*From a paper by J. H. Gray, "The Electric Furnace in the Foundry." See reference 7.

(Copyright, 1921, by Alfred Stansfield)

steel foundry. It consists of a circular steel box lined with refractory materials and having three electrodes which enter through the dome-shaped roof. The furnace rests upon a steel platform which hinges about an axis passing just under the spout, so that in pouring, the spout remains nearly stationary. The tilting mechanism is electrically operated and lifts the furnace by means of connecting rods attached to a large gear wheel; a heavy counterweight being provided to balance the weight of the furnace. On starting the tilting machinery the furnace rises until it assumes the position shown by the dotted lines. Further motion of the machinery, in the same direction, will bring the furnace back again to its normal position. There is therefore no danger of accident through forgetting to stop the motor.

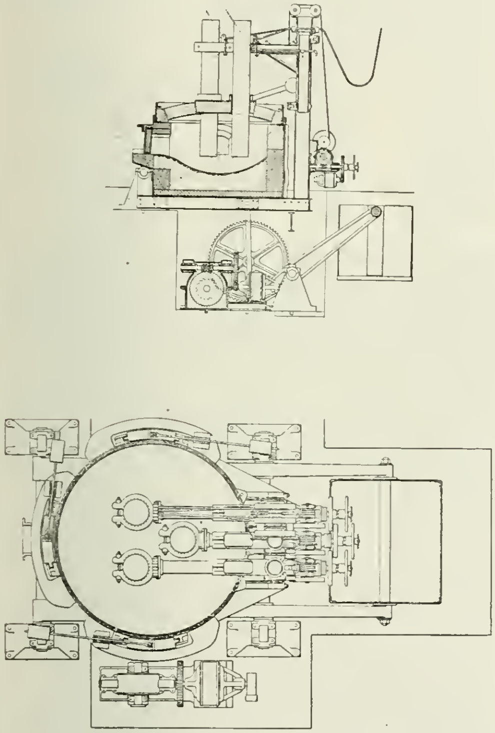

Fig. 13—Heroult furnace of three tons capacity.

In the case of larger furnaces it is usually less important to keep the spout stationary, and in order to lessen the work of tilting, the hinging axis is placed underneath the furnace, instead of at the spout, or the furnace may be placed on rockers like a tilting open hearth furnace, as shown in Fig. 14.

The electrodes are supported by a vertical steel mast or standard attached rigidly to the base of the furnace, so that the electrodes and their holders tilt with the furnace. For each electrode there is a carriage that rides up and down the mast, being operated by a steel rope from an electric motor near the base. Each carriage supports a jib arm, extending towards the electrode, and attached to this, but insulated from it is a water-cooled holder which supports the electrode and supplies the electric current. Insulated copper conductors lead from the electrode holder, above the top of the carriage, to the flexible cables that connect to the low tension bus-bars; these cables being long enough to permit the tilting of the furnace.

The furnace itself consists of a circular steel box, having two charging doors and a spout, which is also closed by a door. The roof is a domed arch of silica brick, usually nine inches thick, and built in a circular steel ring so that the whole roof can be lifted off the furnace, when worn out, and can be replaced by a new one. The upper walls of the furnace, which are 14 or 18 inches thick, are also built of silica brick, while the lower part of the walls and the hearth may be either acid or basic. An acid or silica-lined furnace is lined with silica bricks throughout; the brickwork is brought nearly to the desired shape of the hearth and is then covered with silica sand which becomes fritted together and form the working hearth. A basic furnace has magnesite bricks for the lower walls and over the bottom plate, and a thick bottom of burnt magnesite is built up to the desired form as shown in Fig. 13.

This basic hearth-lining consists of strongly calcined grain magnesite to which from 10 to 20 per cent of open hearth slag has been added for the purpose of forming a permanent bond when the hearth is heated. One method of making the hearth is to mix the magnesite and slag with hot tar or pitch so as to make a plastic mass, and to ram this into the furnace to the required depth with hot rammers. A bed of coke is then laid on this hearth to form an electrical contact, the electrodes are lowered, and the hearth is gradually heated to drive out the volatile matters, thus leaving a coked mass; ultimately the slag in the upper layers fuses, and thus a compact hearth is formed. By this process, however, it is not possible to sinter the hearth as far down as the brick work, and a more satisfactory way is to add the burnt magnesite and open hearth slag in thin layers; heating each layer to the sintering point before adding the next layer. For this purpose the use of coke, as a conductor, is inconvenient as it would have to be completely removed before the next layer of magnesite could be added, and the method adopted is to use an "electrode star" supported on piers of magnesite brick, for the purpose of completing the electric circuit between the electrodes (12).† When the hearth is thoroughly heated, it becomes an electrical conductor and the arcs can be maintained between the electrodes and the hearth itself, thus permitting additional magnesite to be introduced and sintered into place until the hearth is built up to the desired thickness.

The electrodes are circular rods of amorphous carbon or of graphite, the former varying from about 8 inches to 24 inches in diameter. These electrodes are made in lengths of about five feet which are connected end to end by threaded joints, using molded carbon nipples. As each electrode burns away in the furnace it is gradually lowered until the jib arm gets too near the roof of the furnace; a new length of electrode is then added and the holder is raised and slackened so as to allow the electrode to slide through it for a suitable distance. The holes in the furnace roof cannot be made to fit the electrodes closely, but a water-cooled collar, which rests on the roof, fits around the electrode and prevents any considerable escape of flame or hot gases from the furnace. This collar also serves to keep cool the portion of the electrode that is above the arch. That part of the electrode within the furnace wears away on account of volatilization of carbon from the strongly heated tip from which the arc passes. Apart from this the electrode wears to some extent by oxidation as a result of air finding its way into the furnace, and on this account great care should be taken to keep the door as tightly closed as possible. Above the arch of the furnace the electrode should be too cool to burn and this part of the electrode should be kept as short as practicable since its length increases the loss of electrical energy.

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†See references at end of this section.

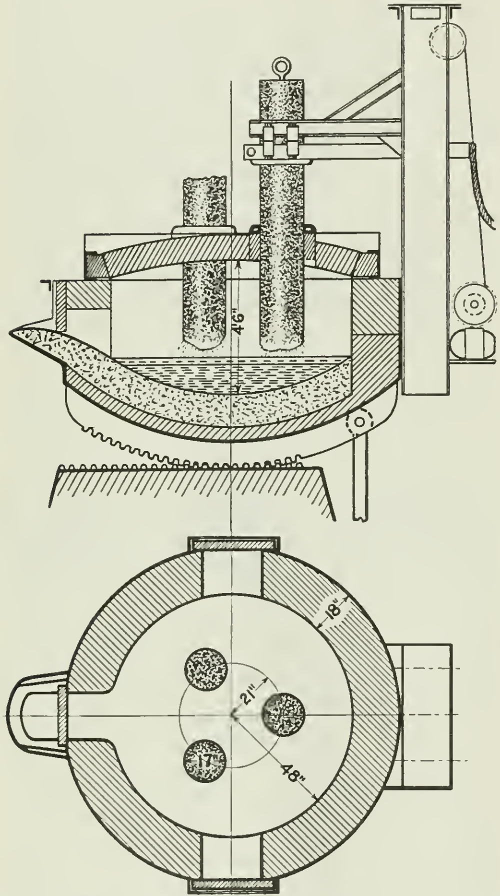

Fig. 14—Six-ton Heroult furnace.

Figure 14 is a sectional plan and elevation of a 6-ton Heroult furnace drawn approximately to scale and showing the principal dimensions. The hearth is basic, consisting of magnesite brick and a lining of crushed magnesite. The electrodes are grouped somewhat closely as is necessary to avoid local overheating of the walls; the circle passing through the electrode-centres has a radius of 21 inches, which is about three-sevenths of the inner radius of the furnace wall, which is 48 inches. The electrode support consists of two parts: the upper arm is attached to the carriage which moves up and down in the mast, while the lower arm which consists of a copper conductor and water-cooled electrode-clamp is supported by, but insulated from the upper arm. The machinery for tilting the furnace is not shown, it would be similar to that in Fig. 13.

The Heroult furnace is built in one, two, three, six and ten gross-ton sizes for melting cold scrap, and of 30 tons capacity for refining molten steel. The following table (7) shows the electrical power per ton, the transformer capacity and the corresponding current in amperes carried by each electrode:

Table 7.

Size of Furnace Tons	Power per ton, kva.	Transformer Capacity, kva.	Amperes for each electrode
1	500	500	3,000
2	400	800	4,800
3	330	1,000	6,000
4	300	1,200	7,500
6	250	1,500	9,000
10	225	2,250	13,500
15	200	3,000	18,000
25	150	3,750	21,500

The electrical power per ton of furnace capacity has been increased, during recent years, with a view of obtaining a better efficiency during the melting period, though decidedly less power can be used during the refining period on account of the danger of melting the walls and roof. The power per ton of steel in the furnace decreases as the furnace becomes larger because the loss of heat per ton is less in the larger sizes. The 25-ton furnace, which holds 30 tons of steel and is used for refining molten steel and not for melting steel scrap, only needs from 100 to 150 kva per ton.

The electric current, in amperes, supplied to each electrode is obtained from the kva supplied to the furnace by the formula: $\text{kva} = \frac{\sqrt{3}\,VA}{1000}$ where A is the number of amperes per electrode and V is the voltage between any two electrodes. If V is taken as 100 volts we find that A is 5.8 x kva, and in the table the ratio 6 has been used.

The electrodes are usually made of amorphous carbon, but graphitized electrodes are sometimes used. The sizes of these electrodes could be calculated from Carl Hering's data,* but in general they are made somewhat stouter than is indicated by these considerations. Table No. 8 shows the sizes that

Table 8.

Sizes of Electrodes for Heroult Furnaces.

		Carbon Electrodes		Graphite Electrodes	
Size of Furnace Tons	Amperes per Electrode	Size of Electrode inches	Amperes per sq. inch	Size of Electrode inches	Amperes per sq. inch
1	3,000	8	60	4	240
2	4,800	12	42	6	168
3	6,000	14	39	7	156
4	7,500	14	49	7	196
6	9,000	17	40	8	160
10	13,500	20	43	10	172
15	18,000	24	40	12	160
25	21,500	..	..	..	..

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*Stansfield, The Electric Furnace, pages 98-108.

are used in practice and the resulting current density. The consumption of carbon electrodes varies from about 30 to 35 pounds per ton when melting scrap steel, and from 8 to 12 pounds when refining molten metal.

The electric current is carried from the transformers to the furnace by means of copper bus-bars which are interlaced so as to keep a high power-factor. Bare flexible cables must be used at one point to enable the furnace to tilt. The bus-bars may be made to carry 800 to 1000 amperes per square inch of cross-section and the flexible cables can carry 800 to 1000 amperes per 1,000,000 circular mils, as shown in the following table:

Size of Copper Conductors for Each Electrode of Heroult Furnace.

		Bus-bars		Flexible cables
Size of Furnace Tons	Amperes per Electrode	Square inches Section	No. and width of ¼-inch bars	No. and size
1	3,000	3	2 of 6-inch	4 of 750,000 cm.
2	4,800	5	4 of 5-inch	6 of 800,000 cm.
3	6,000	6	4 of 6-inch	6 of 1,000,000 cm.
4	7,500	7	4 of 7-inch	8 of 1,000,000 cm.
6	9,000	9	6 of 6-inch	6 of 2,000,000 cm.
10	13,500	16	8 of 8-inch	8 of 2,000,000 cm.
15	18,000	24	12 of 8-inch	12 of 2,000,000 cm.
25	21,500			

Heroult furnaces are used for melting cold scrap for the production of steel castings, high-speed tool-steel, various special tool-steels and alloy-steels. They are also used to some extent for melting iron for gray iron and malleable iron castings. The larger sizes are used for refining molten steel that has been made in the Bessemer converter or the open hearth furnace.

The power consumption for refining molten steel will vary from 100 to 200 kw-hours per ton, while for melting cold scrap some 600 to 900 kw-hours will be needed. The yearly load-factor of an electric furnace, on continuous operation, will range from 45 to 50 per cent, while the daily load-factor will be between 50 and 55 per cent.

The following is a summarized list of Heroult furnaces building and operating in the United States and Canada and licensed by the U. S. Steel Corporation on the first of September, 1919.*

Heroult Furnaces in United States and Canada.

Size of Furnace	Number	Products
¼ ton	1	Cast Steel
1 ton	8	Castings and Ingots
2 ton	25	Castings and Ingots
3 ton	24	Castings and Ingots
4 ton	2	Ingots and molten ferro-manganese
5 ton	1	Ingots
6 ton	75	Castings, ingots and pig iron
10 tons	2	Ingots
15 tons	7	Castings and ingots
25 tons	4	Ingots
40 tons	2	Ingots

The 25-ton Heroult furnace has been used for making steel by the triplex process at South Chicago; molten pig iron being blown in Bessemer converters, then transferred to open hearth furnaces for the removal of phosphorous, and after that to electric furnaces for removing the oxides, sulphur and gases.

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*The author wishes to express his indebtedness to Mr. J. H. Gray and Mr. R. L. Baldwin of the U. S. Steel Corporation for information with regard to the construction and operation of Heroult furnaces.

ASSOCIATION OF IRON & STEEL ELECTRICAL ENGINEERS.

The Association of Iron & Steel Electrical Engineers will hold its 15th annual convention during the week of September 19 to 24, 1921, at the LaSalle Hotel, Chicago, Illinois.

The two most important features of this convention will be:

First—The educational feature which will comprise exhibits of the various electrical manufacturers of the United States. In 1919 this plan was tried out with success. In 1920 while the exhibition was tripled with regard to space, it still was not sufficient to gratify the demands of the electrical manufacturers. The increase in the interest of the exhibitors in 1920 over that of 1919 was caused by the enthusiasm displayed by the active members of our association (electrical, mechanical and combustion engineers in the steel mills). It is the intention of the association this year to make the educational feature just what such an exhibit should be, namely, acquainting the steel mill engineers with the latest developments in steel mill apparatus. In fact, the steel mill engineers feel that this is the only opportunity presented to them whereby they can secure first hand knowledge of the products necessary for successful operation in the steel mills.

Second—The technical sessions which will consist of morning and afternoon meetings devoted to papers of engineering interest to the steel mill engineers. The steel mill authors will be: R. B. Gerhardt, electrical superintendent, Bethlehem Steel Company, Sparrows Point, Md.; R. W. Cousins, electrical engineer, Illinois Steel Company, Gary, Ind.; Wray Dudley, electrical superintendent, Ashland Iron & Mining Co., Ashland, Ky.; W. N. Flanagan, steam engineer, Ohio Works, Carnegie Steel Company, Youngstown, O.; F. E. Leahy, fuel and expert engineer, Carnegie Steel Company, Duquesne, Pa.; G. R. McDermott, assistant chief engineer, Illinois Steel Company, South Chicago, Ill.

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A New Balanced Sheet Mill Drive

Josef Hirschmann, Chief Engineer of the Eastern Rolling Mill Company, Designs a New Drive Which Overcomes the Difficulties Encountered by Sheet Mills Driven by Pinions.

By **JOSEF HIRSCHMANN,**
Chief Engineer of the Eastern Rolling Mill Company.

FOR a hundred years or more balanced roughing rolls on sheet mills, have been driven by pinions despite the high cost of first installation and the expensive upkeep, to say nothing of the waste of power of this type of drive. This has been true because no other satisfactory means of doing this work had been devised, but with the great development of the sheet mill business during and since the war, and especially in the production of high-grade sheets for automobile and metal furniture work, where the necessity for a separate roughing stand became imperative, many mill superintendents, to save the extra expense of a pinion stand, adopted the old expedient of a jump roughing mill, in which the top roll is driven by friction. This expedient has always been more or less of a makeshift and it is an open question whether the results obtained by this means ever entirely justified the saving in price from the first cost of a balanced mill.

The jumping up of the top roll on entering the sheet bar, especially on the thicker sizes, with the consequent pounding and battering up of the ends of the housing screws, which sooner or later results in crystalizing and final breaking of the screws, the reduction in output of the mill due to less draft being used in order to prevent gagging of the top roll, and the limit in thickness of bars that can be successfully roughed on a jump mill, have always been a source

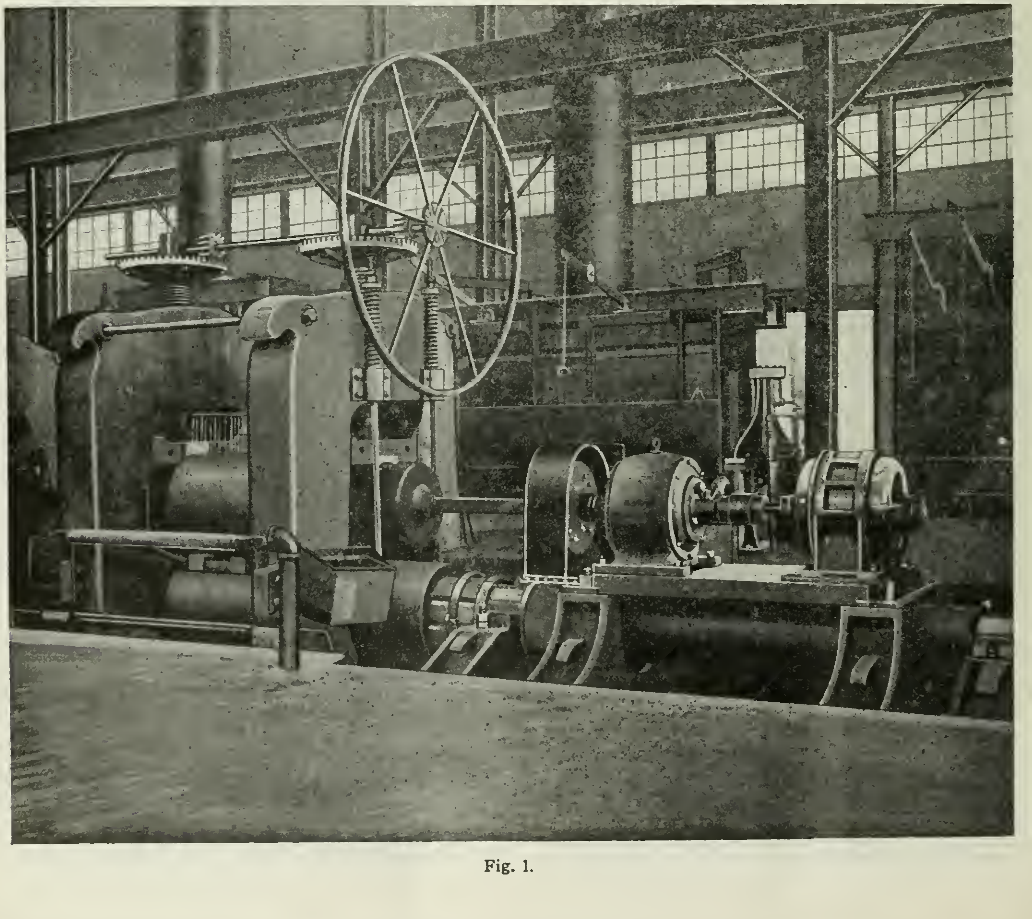

Fig. 1.

of annoyance and expense to the progressive mill superintendent.

This has resulted in the engineering genius, devoted to rolling mill construction, turning his attention to the task of solving the problem of a practical and comparatively cheap means of driving a balanced top roll.

The accompanying illustration shows a novel device designed by Josef Hirschmann, chief engineer of the Eastern Rolling Mill Company of Baltimore, Md., and assigned to the National Roll & Foundry Co. of Avonmore, Pa., who built and installed a number of these drives on the roughing sheet stands of the Eastern Rolling Mill, displacing the pinion stands previously installed.

This drive consists of a 25 hp motor at 750 rpm direct connected to a speed reducing gear transmission by means of a flexible coupling.

The transmission is a very compact nest of cut gears, with a speed reduction of 25 to 1 enclosed in a cylindrical oil tight cast iron case, permitting the gears to operate submerged in heavy oil, the same as an automobile transmission.

The central shaft of the gear transmission running at 30 rpm at the slow speed end is connected through a slip ring clutch to a short spindle and thence through an ordinary coupling box to the warbler of top roll, thus giving an ideal flexible connection, which permits the top roll to be raised or lowered to suit the thickness of the various sizes of sheet bars.

The slip ring clutch is so arranged that any excessive load, that might for any reason be thrown on to the motor beyond its stated capacity, will permit the ring to slip and prevent injury to the motor. This is taken care of by four cast iron brake shoes, held in contact with the face of the ring by an adjustable spring pressure.

However, there would be little use for this safety device as the speed of top roll is slightly slower than bottom one so that when the bar is entered into the rolls the top roll instantly becomes a friction driven roll, taking all the rolling load off the motor by running slightly ahead of the drive and dragging the armature of the motor along with it, in the direction of its rotation, thus taking care of any ordinary difference in speed between the two rolls.

Immediately the bar is out of the rolls the motor automatically takes up its task of keeping the idle top roll in motion. This arrangement does not require any special roll and any standard roll, such as a worn out finishing roll, may be used in the roughing stands.

The motor and gear transmission are rigidly bolted to the same base plate, this being superimposed upon two cast iron yoke castings straddling the roll pit, resting upon and bolted to the shoe plate on each side of pit.

These yoke castings are hollowed out at the center of the pit so that the bottom driving spindles which drives the mills through the main mill motor are free to revolve out of contact with either yoke. This gives a self contained driving unit for top roll which can be readily removed when changing rolls.

Another very desirable feature is the spring balance for top roll, attached to side of housings as shown, and through levers attached to top roll carriers, raises the top roll to the desired height when the housing screws are slackened, making a balance that is self contained with housing and permitting the housing to be moved endwise at will when changing rolls, without previous preparation, such as blocking up of weights, as was necessary on the old weight balanced mill.

INFLUENCE OF INSUFFICIENTLY BURNT LIME.

The basic open hearth process has for its object the elimination of the phosphorus from the bath by combining the phosphoric acid, formed during melting with oxide of lime, the favorable progress of the operation depending mainly upon the physical and chemical condition of the lime.

The amount of lime used must be enough to produce a phosphate of lime, $4\,CaO\,P_2O_5$, which contains 61.20 per cent lime and 38.38 per cent P_2O_5, corresponding to 16.93 per cent phosphorus, while at the same time by the formation of silicate of lime $CaO\,SiO_2$ the silicon in the bath becomes neutralized and does not counteract the dephosphorization.

Difficulties in transportation sometimes cause a prolonged standing of the cars loaded with the lime on a railroad siding, during which standing the wagon covers may become more or less spoiled. Weather influences then change the oxide of lime into the hydrate, which is blown from the furnaces in the form of dust. This in turn causes an incomplete dephosphorization and very noticeable loss of heat.

Raw limestone contains 45 per cent CO_2 which is driven off by the burning.

Samples of lime containing 11.25 per cent CO_2 going as high as 23.08 per cent; 25.63 per cent $CaCO_3$ reaching up to even 52.45 per cent are nevertheless burnt only to three-fourth and to one-half. In this connection, however, it must be kept in mind that the way the samples are taken has a big influence upon the result.

It is proper to take from every carload a shovelful from the top, one or two from the center and one from the bottom, grind the samples, mix and analyze. The loss from burning should not exceed 3 to 6 per cent CO_2.

After the carbonate of lime is introduced into the bath it decomposes into CaO and CO_2. The temperature of the charge decreases. According to Backheuer (Stahl und Eisen 1918, page 748), the oxygen of the carbon dioxide seems to combine at the same time with the manganese of the bath. This bath is saturated with metallic oxides, which require a larger quantity of de-oxidizers. Since the manganese does not protect any longer the bath from the oxidation by the air, especially when the bath in the mixer does not contain more than 1 per cent of manganese, a loss of higher heat and a smaller quantity of steel will be the result of the action of the sulphur.

The heat loss is furthermore increased by losses due to the cooling of the bath by the decomposition of $CaCO_3$ and by violent reaction.

The decomposition of the carbonate of lime is not completed even towards the end of the operation. In fact, numerous bullets of from 2 to 10-inch diameter, float on the surface of the bath, lowering the temperature and hindering the flowing out of the slag by obstructing the tapping hole.

The inner part of these bullets consists of $CaCO_3$. It is surrounded by a cover of CaO and slag.

The February, 1921, issue of the "Revue de l'Ingenieur"

Electric Annealing and Heat Treating Furnaces

Definition of Annealing, Quenching, Drawing and Tempering in Relation to Heat Treating Furnaces—General Characteristics of Electric Furnaces Discussed.

By GEORGE P. MILLS,
Electric Furnace Construction Company, Philadelphia, Pa.

IN order to better appreciate the present status and future possibilities of the electrically heated furnace as applied to the annealing and heat treatment of steels, it might be well to consider, briefly, these processes from a metallurgical point of view.

Although annealing, hardening, quenching, and drawing or tempering are familiar terms, I would like to define them for the purpose of this paper, in order to outline the field of the electric heat treating furnace to better advantage. All of these processes, of course, involve heating the metal up to temperatures which depend on the analysis of the steel, holding at these temperatures a certain period and cooling at varying rates.

The term "annealing" may be sub-divided into three headings:

First—Normalizing, which consists of heating the steel either above or just below the critical temperature, removing from the furnace and cooling in air. This process when applied to steel castings, relieves the casting strains, brought about by uneven cooling when the castings are stripped and eliminates the hard spots, which make machining difficult.

Second—Straight annealing which consists of heating above a critical temperature and holding for a short time, then cooling slowly by cutting off the heating medium and allowing the material to cool with the furnace. In continuous or semi-continuous furnaces, the material passes through a cooling chamber, so that the heat content of the heating furnace walls is retained, economy improved and production greatly increased. This treatment is used to turn out the highest grade of steel castings. Not only are the machining qualities of the castings improved, but the elongation is greatly increased at only slight expense of the ultimate strength. This form of annealing is also applied to tubes, wire, strip steel and other products that are cold rolled or drawn, in order to relieve the strain set up due to cold work.

Third—Dead annealing, which consists of heating the charge, soaking it a considerable time at the temperature, then cooling in the furnace at a predetermined rate, say 5 degrees or 10 degrees per hour. This process is used on high carbon alloy steel, such as ball bearing stock and other classes where absolutely uniform hardness tests are required. One reason for requiring this class of treatment is the finishing of the product in automatic machines, where any variation in the hardness might result in spoiled work and decreased production.

The hardening process consists of heating the metal to above the critical point and quenching. The degrees of hardness depend on the rate of cooling in the quenching. The more rapid the cooling, the harder and more brittle will be the steel.

Tempering or drawing consists of re-heating steel which has been quenched to a temperature below the critical point, varying from 450 to 1,150 degrees F., depending on the characteristics desired and cooling in air. The object of tempering is to eliminate the strain set up in quenching, render the steel more ductile, while retaining the high tensile strength produced in quenching.

Various physical characteristics can be obtained in a given steel by varying the temperature and the time element of treatment. Another important consideration in most of these treatments is that while it is essential to carry the temperature above the critical point, it is very desirable to keep very near the critical. Any excess above that actually required, tends to coarsen the finished product. In some types of furnaces, where it is impossible to determine just what is going on in the furnace, it is a usual practice to run the temperature 50 to 100 degrees F. above the actual critical as a factor of safety. In hardening and annealing, excessive time is usually allowed for soaking, in order to be quite sure that the entire mass of the part to be treated is up to temperature.

From the standpoint of the temperature and time element control, the electric furnace is ideal and is being considered in all cases where exceptionally high grade material is to be turned out. Other characteristics of the electric furnace are also being brought to the steel manufacturers' attention and undoubtedly large installations will shortly be made for the production of less expensive material.

The electric furnace of the ni-chrome ribbon resistor type consists essentially of a strongly fabricated steel shell with a heavy thickness of high grade heat insulating brick, laid in three or four courses, with all joints broken. The firebrick lining of the furnace is bonded to the heat insulating brick so as to produce a solid rugged furnace wall of from 13 to 20 inches thick. The heating element consists of ni-chrome ribbon, which is exceptionally heavy and rugged. These ribbon elements are distributed over the inside walls and in some cases, the roof of the furnace, on insulating hanger brick which are built into the firebrick lining.

A single length of ribbon constitutes each phase. Where splicing is necessary, the joint is heavily reinforced and welded. The phase terminals are brought through the furnace walls in close fitting insulating bushings to connection blocks on the outside

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*Abstract of paper presented before the Philadelphia section of the Association of Iron & Steel Electrical Engineers and published in full in their February proceedings.

of the furnace. The phases may be connected either delta or Y to the power circuit, through the control panel.

As to the life of the ribbon, there are furnaces which have been operating for over two years and the ribbon shows no deterioration.

There is no reduction in area of the cross section of the ribbon due to erosion, but there is also no deterioration or crystallizing of the structure of the ribbon.

In fact, the maintenance and repair charges on the ribbon resistor type of furnace installed, have been negligible. At the temperature involved, the maximum never going higher than 1,800 degrees F., the firebrick used, as well as the hanger brick, have a coefficient of expansion very nearly zero. The result is a tight furnace, in which all mechanical strains are reduced to a minimum. The lining does not crack, spall or run. These facts are important, of course, not only from the standpoint of small maintenance costs, but there is no lost production due to shut-downs for repairs. Due to the fact that the ribbon resistor may be formed in any reasonable shape and distributed over the interior of the furnace, remarkably uniform temperatures are obtained throughout the furnace. The ribbons are distributed so that extra heat energy is dissipated inside of the furnace at the points requiring the most heat, in order to maintain uniform temperatures.

An example of this is shown by the gun treating furnace now being installed by the Electric Furnace Construction Company, which has inside dimensions of 36 feet deep by 6 feet in diameter, has a capacity of four 6 inch naval gun forgings weighing 50,000 pounds per charge. The furnace is divided into six heating zones, each controlled by an individual automatic panel. The radiation losses on the bottom and top zones are greater than on the intermediate zones, also the amount of metal to be heated is greater in the top and bottom zones than the intermediate zones. For this reason, 138 kilowatts is installed in each end zone and 110 kilowatts in each of the intermediate zones, the total installed capacity being 716 kilowatts. This arrangement insures uniform temperatures in the gun forgings throughout their entire length at all times, both during the period required for coming up to temperature and during the soaking period.

In the smaller furnaces where a single control is used, additional heat is generated near the doors by doublng the heating element back for a short distance, thus developing twice the Btu in this position of the furnace where the radiation losses are greatest.

The temperature control, which is the most important feature of the electric furnace, is operated by the "on and off" principle, that is, power is cut off when the temperature of the furnace reaches a predetermined setting and is cut on again when it falls to a predetermined setting. This operation is accomplished by means of a thermocouple which is placed on the surface of the charge, actuating a recording controller. The sensitivity of the control instrument is plus or minus ¼ of 1 per cent of the range of the chart, that is, if the chart of the instrument has a scale of from 200 to 1,800 degrees F., the range would be ¼ of 1 per cent of this range, or 4 degrees.

The "on and off" principle of temperature control has a number of advantages over the variable voltage control, in that the heating elements are designed for operation on standard power voltages, 110, 220, 440 or 550 on either single, two or three phase, 25 or 60 cycle or dc. Often, excess capacity in the existing power transformers can be used to advantage in the electric furnace. In cases where additional transformers have to be installed to take care of the furnace load, these transformers are of standard type and may be purchased to line up with existing power transformers.

The fact that the load is thrown on and off suddenly will produce no disturbance in line. On large furnaces as in the case of the gun furnace just cited, the power is controlled in sections so that only a small part of it is actually thrown on or off at any given instant. The usual maximum of a single zone is somewhat less than 250 kilowatts. The chief advantage of this method of control, however, is that it is entirely automatic and eliminates the manual operation which is necessary in rheostatic or transformer tap control.

The space occupied by the furnace is small compared with other types, especially when account is taken of the space required by fuel fired furnaces for accessory apparatus and fuel storage.

The working conditions around the electric furnace are excellent. It is cool and there are no fumes, no dirt, no noise.

Two important considerations to be taken up in the laying out of a new furnace are:

1. The relation of the size of furnace to the output. The electric furnace should be loaded to capacity at all times. If the production is expected to vary widely, two or more furnaces should be installed to insure capacity operation on the ones that are running.

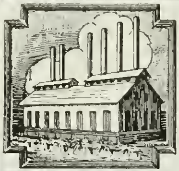
2. Handling equipment and devices should be coördinated nicely with the furnace. High grade work can easily be spoiled in handling from the furnace, regardless of the fact that the furnace itself might be working perfectly.

It is the function of the furnace engineer to investigate thoroughly all the conditions pertaining to a proposed installation before making recommendations, and this, of course, can only be well done when full coöperation is given by the operating engineers. Much of the progress that has been made in the electrometallurgical field in melting, refining and heat treating may be credited to electrical engineers, associated with the steel plants, and the progress which is made in the future in the use of this latest perfected electric furnace largely depends on the interest taken in it by members of this association.

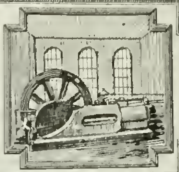
1921 ANNUAL MEETING.

The twenty-fourth annual meeting of the American Society for Testing Materials will be held at the New Monterey Hotel, Asbury Park, N. J., from June 20 to 24 inclusive. Monday, June 20, will be devoted to committee meetings. The first session of the annual meting will be on Tuesday morning, June 21, and the closing one on Friday evening, June 24. In about a month a provisional program including announcement of entertainment features will be sent to the members.

From present indications the meeting in June will be the largest the Society has ever held. Probably in no year in the Society's history have committee activities been greater, and a number of interesting and important reports are in prospect. Separate sessions will be devoted to several important subjects.



STEAM POWER DEPARTMENT



Development of Mechanical Soot Blowers

Recording Some Most Recent Tests of Mechanical Soot Blowers With Coal, Pulverized Fuel and Oil—Marked Increases in Boiler Efficiency Are Shown by Use of Mechanical Soot Blowers.

By ROBERT JUNE,
Mechanical Engineer.

PART II

SOOT as found in steam boilers varies considerably in appearance and composition, depending upon the grade of coal burnes, conditions of combustion, and part of the furnace from which the sample is taken. Nearest the fire the deposits formed consist largely of ash. Analysis of samples of soot, taken from a boiler, shows in addition to the "pure soot" the presence of silica, alumnia, iron oxide, various alkalies and sulphur dioxide.

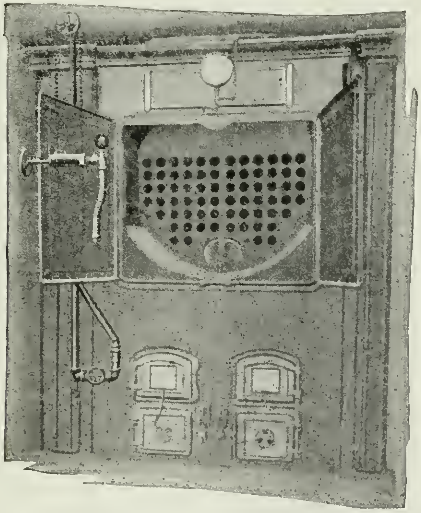


Fig. 1—Typical installation of Diamond Soot Blower system on a horizontal return tubular boiler. Door is shown transparent in order to show piping and method of operating main blower valve from floor.

In all but the coolest portion of the setting, soot is usually gritty in texture. The grains may be as large as medium size sand or as fine cigar ash. These particles are in a plastic state when they leave the furnace and striking the boiler they adhere to the tubes. If this deposit is not removed frequently it quickly increases in amount and changes in character. The carbon burns out in part and the mass cements together. The repeated reduction in heat-absorbing surface increases the temperature of the flue gases so that the process of cementation is continuous and constantly increasing in intensity. If extremely hard, clinker-like formation results. In a short time the tubes in some portion of the boiler are thickly coated, thus materially reducing its capacity.

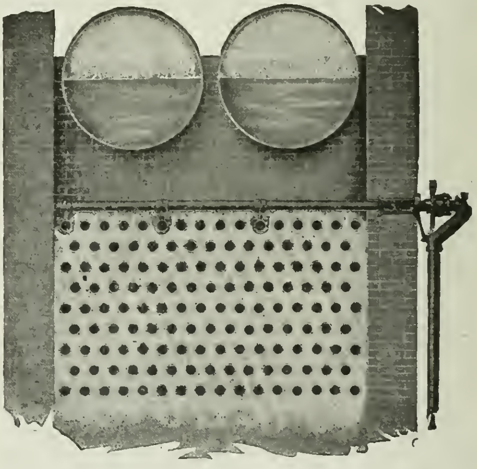


Fig. 2—Detailed view of the Diamond Model G revolving unit installed in a horizontal water tube boiler. The method of supporting blower units on tubes, and the position of the units and nozzles relative to the tubes, is practically the same on all types of horizontal and vertical water tube boilers to which this system can be applied. Notice there is a Venturi nozzle for every space between the rows of tubes.

In our discussion last month we dealt with figures of actual tests conducted to determine the efficiency of mechanical soot blowers with various types of fuel, such as anthracite and bituminous coal, pulverized fuel and oil. We found that mechanical soot blowers would effect a saving of 4 to 8 per cent in fuel and also effect an important reduction in labor, so that the importance and value of mechanical soot blowers was self evident.

The Five Essentials in Preventing Soot Waste.

The five essentials in preventing soot waste are:

1. Frequency of cleaning in order to minimize the cumulative effects of increasing deposits. Tubes should be cleaned three or four times in 24 hours.
2. Thoroughness of cleaning, in order to maintain high furnace and boiler efficiency, and prevent the corrosive effects of soot accumulation.
3. Availability of system. The soot cleaner system should be instantly available, automatic in action, capable of rapid operation.
4. Durability of system: The blower units should be so designed and constructed that they will withstand the stress of hard service without the necessity for frequent repair or replacement.
5. Economy in operation: The soot removing system should be cheaper in operation than hand blowing; it should be so installed as to prevent the entrance of cold air into the furnace during its operation, it should not interfere with the operation of the boiler; it should pay for itself from an investment standpoint.

Soot Blowers for Horizontal Return Tubular Boilers.

Soot blowers were first manufactured on a commercial basis for Scotch marine boilers on the Great Lakes. The blowers were what is known as the "Rear end" type, being installed through an opening in the water leg in the rear. It was only natural therefore, when soot blower manufacturers began to develop equipment for stationary horizontal return tubular boilers that they should start in by adopting the rear end blower on Scotch Marine boilers for this purpose.

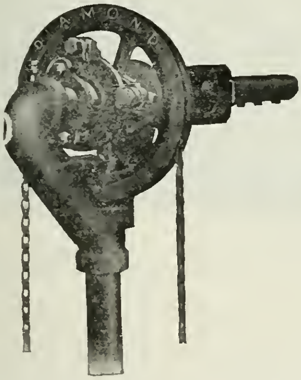


Fig. 3—Head of Model "G" Unit used on water tube boilers. Note the strong symmetrical construction. The use of the gooseneck permits the steam main to be brought close to the boiler setting, thus adding greatly to the appearance of the installation.

For a good many years it was the universal practice of all soot blower manufacturers to make only rear end equipment for horizontal return tubular boilers. The rear end blower had numerous disadvantages, however, and about 8 to 9 years ago soot blower manufacturers generally began to produce front end blowers. While rear end blowers can still be purchased from one or two of the older manufacturers, they are seldom recommended, and practically every manufacturer of this type of equipment manufactures and recommends the front end blower to the exclusion of the older type.

A typical installation is shown in Fig. 1. This consists of a blower arm inset with Venturi nozzles and placed at the front end of the boiler. The position and arrangement of the blower are such that when it revolves, the nozzles direct the steam jets directly into every tube of the boiler. With an initial pressure of 150 pounds this steam is shot from the nozzles at a velocity of approximately 2,700 feet per second. As can be imagined, the effect is to remove every bit of the soot and fine ash deposit.

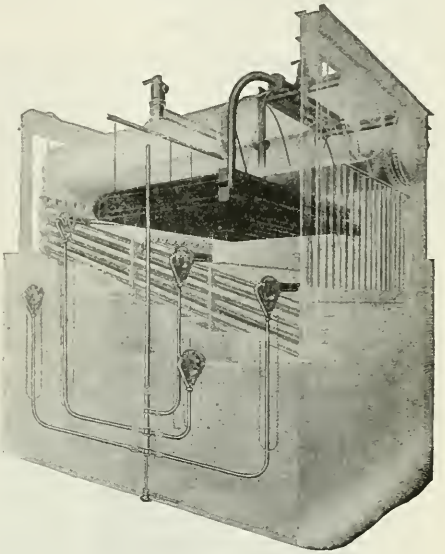


Fig. 4—Application of the Diamond Mechanical Soot Blower system to horizontal water tube boiler, vertical baffle type with superheater.

The blower unit is attached to the door, and when the door is opened the entire mechanism swings with it, leaving the boiler ends free and clear for inspection, repairs, etc., and exposing and making easy of access any part of the blower.

Both the tubes and the combustion chamber are cleaned at the same time. The sweeping of the arm as it swings in a complete circle allows the steam to be shot directly into the tubes on a straight line and the corner tubes are taken care of with the same thoroughness as the center ones.

The blower being at the front end of the boiler, and the entire mechanism controlled from the outside, it is easy to get at and operate, making the cleaning of the boilers three or four times a day a simple process. Each operation will consume only about a minute's time.

One of the most important advantages in the use of mechanical soot blowers is the absolute exclusion of cold air from the boiler. The boiler doors are always shut tight when the blowers are in operation, and it makes no difference what load the boiler is under. In fact, the more the boilers are being forced, the more need to clean the tubes. This cleaning cannot be done with a hand hose without reducing the load. It can be done in a few moments right at the peak of a load with mechanical soot blowers and all of this is accomplished without any reduction in efficiency caused by admission of air.

Equipment for Water Tube Boilers.

For cleaning water tube boilers of the usual horizontal type, vertically baffled, and for cleaning most types of vertical boilers and economizers, the equipment supplied by the principal manufacturers commonly consists of a permanent installation of revolving units located at various points in the passes of the boilers. In a typical installation, Figs. 2 and 3, the equipment consists of five principal elements, as follows:

1. A head through which the steam passes from the main soot blower supply line when the valve is opened. The head is the foundation element to which the other elements are attached.
2. A wall box which is bricked into the setting. The box supports the unit, and is so constructed that the blower can be turned freely without admitting air to the inside of the setting.
3. A blower element running cross-wise of the bank of tubes and consisting of a small header with nozzles so placed as to discharge steam between the boiler tubes.
4. A sheave or hand wheel by means of which the blower element is rotated.
5. Bearings attached to the boiler tubes which support the blower element and permit it to revolve freely.

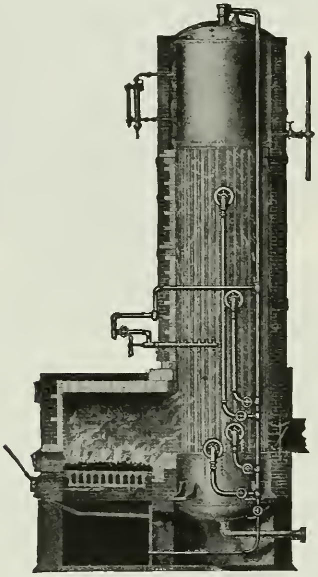


Fig. 5—Installation of Diamond Soot Blowers on Wickes vertical boilers.

Soot Blowers for Horizontal Water Tube Boilers.

The general arrangement of the units in horizontal water tube boilers consisting of a single bank of tubes is shown in Fig. 4. It will be noted that a unit is shown over the arch at the bottom of the first pass. This is extremely important in as much as this is the point where the gases first strike the boiler and where the largest deposits of soot and ash are to be found. This is also the hardest working part of the boiler, as the temperatures are highest here and the transfer of heat to the water is most rapid.

In order to maintain this rapid transfer of heat, the deposits of soot and ash must be removed at frequent intervals. As the temperatures are extremely high at this point, the problem has been presented to soot blower manufacturers in designing a unit which would stand up and perform its functions satisfactorily. The problem has been solved by treating the unit by a special process known as "calorizing" to prevent the burning of the metal at high temperatures and by placing the unit close against the front header of the boiler behind an arch that the blower unit will stand up in this location for six months to three years and in some cases even longer. As the cleaning of this part of the boiler is of vital importance, power plant operators have found that they can well afford to replace the blower pipe of this unit from time to time as conditions warrant.

The second unit is located at the top of the first pass in a position which enables it to clean the superheater as well as the boiler tubes. The frequent cleaning of the superheater is essential to the maintenance of high and uniform steam temperatures, and an individual soot blower unit for this purpose is frequently provided. The remaining units in the boiler are located as stragetic points in the passes.

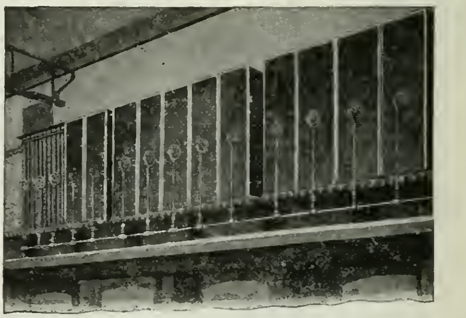


Fig. 6—Independent type of economizer equipped with Diamond Soot Blowers instead of scraper mechanism.

Soot Blowers for Vertical Water Tube Boilers.

The worlds' largest boilers are of the vertical type and it is a notable fact that these large boilers, almost without exception, are equipped with mechanical soot blowers. Proper arrangement of the units is one of the most important factors in the success of these installations. In the Stirling, Connelly, Kidwell and similar boilers thorough cleaning of the tubes at the bottom of the first pass is secured by the installation of calorized units. Temperatures are high at this point and the calorized metal withstands high temperatures without oxidizing.

One of the principal requirements of a successful soot blower installation for vertical boilers is that the system employed shall allow the steam jets to play effectively over the whole gases by unnecessary obstruction. The number and location of the units in vertical boilers varies with the different sizes and types of generators. The number of units will run from five in the small Stirling boilers without superheater to 32 in the big W-type of 2,365 hp, such as are used at the plant of the Detroit Edison Company and other large central stations.

With Wicks boilers, Fig. 5, the problem of design is complicated by the fact that economy in space is one feature of Wicks installation and that the boilers are therefore often set in solid batteries, rendering it difficult to get at the lower part of the rear pass.

Tubes over the arch are cleaned by means of a special removable unit. This unit consists of a multiple jet blower element with one nozzle for each row of tubes. A universal joint of steam-tight design permits easy operation of the unit and insures thorough cleaning of this section of the boiler. The unit is permanently secured to the boiler shell, and when not in use can be withdrawn from the tube space out of the heat—a desirable feature in such installations as have temperatures in excess of 2,000 degrees.

Economizer Installations.

The same type of units used to clean boilers are now being generally used for the purpose of removing soot and ash deposits from economizers, whether the latter are an integral part of the boiler or independent units. Fig. 6 shows the method of installation. The arrangement provides for units extending from front to back of economizer centrally located between the top and bottom and spaced 4 or 5 rows of tubes apart.

We have stated that soot blowers are going into use on economizers, replacing the old type scraper mechanism. The advantage of soot blowers as compared with the scraper are:

a. Elimination of air infiltration. For every 10 to 16 tubes, depending upon the capacity of the economizer, there is a chain provided for the raising and lowering of the scrapers. These chains pass through holes in the top of the economizer. As these holes are always open, air infiltration is a constant source of loss—a loss which is eliminated when soot blowers are installed.

b. One of the conditions always encountered in some degree in economizer installations is the piling up of soot on the bottom headers. While it is true that a space is provided between the headers which would seem to be ample for the soot to fall through into the soot chamber, yet quantities of it are always building up in the space between the headers and eventually bridging over. As this result the action of the scrapers is interfered with and the efficiency of the economizer is affected by reason of the accumulation. This difficulty is always removed by the use of soot blowers.

c. The scraper mechanism takes from 2 to 5 hp of electric power to operate. There is constant charge for power. Scraper maintenance is also one of the most costly features of economizer installation. In addition to the cost of operation and maintenance there is also the handicap of making repairs to the tubes of the economizer. While soot blowers require some operating charges, these charges are very low when compared with scrapers, and in addition the economizer is cleaned more efficiently.

Equipment for Hollow Stay Bolt Boilers.

For hollow stay bolt boilers the soot blowers consist of two main pipes from which extend many branch pipes carrying Venturi nozzles. One of these nozzles enters every hollow stay. The system is so arranged that it clears the hand-hole yokes, permitting them to be removed, and thus making the tubes easily accessible for turbining or repairs without disturbing the blower in the least. The entire equipment is permanently installed on the front water-leg of the boiler, and is operated by two valves only, from the front.

Where boilers are built with horizontal baffles, a number of the nozzles are extended over the baffles for distances of from two to eight feet, thus insuring a high degree of efficiency in cleaning. In addition to the use of blower nozzles extending from the stays, it is at times found possible to equip boilers of this type with revolving units, as well, and this combination equipment offers the most satisfactory method of securing high cleaning efficiency in this type of boiler.

Recent Advances in Design and Construction.

One of the most important recent advances in design and construction from the point of view of increased efficiency is the development of the vertical header type of installation, Fig. A. This design presents many advantages as compared to the old practice of placing the header in a horizontal position which may be summarized as follows:

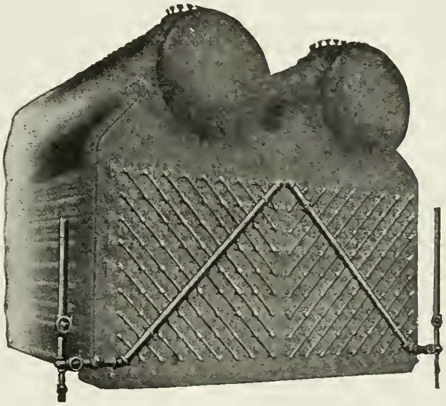


Fig. 7—Installation of Diamond Soot Blowers on water tube boiler with hollow stays.

1. Increased effective pressure of steam at blower nozzles, due to the elimination of a number of right angle joints and the reduction of friction at the fittings.
2. Permits free expansion of all riser pipes, thus preventing any possible binding of the units.
3. Eliminates a number of screw joints with consequent reduction in opportunities for leakage to develop.
4. More securely fitting doors, etc., than when horizontal header or right angle joints are employed.
5. Presents much better appearance mechanically.
6. Permits the use of a much shorter header.
7. Valves are concentrated at one point, facilitating rapid operation.
8. Assures thorough draining.

In addition to these special merits, it can be installed as quickly as the horizontal header with its right angle joints and the cost is, if anything, but little more.

Welded Nozzles.

When nozzles of Venturi section were developed the problem of high velocity as far as soot blowers were concerned was solved for all time. The method of fixing the nozzles in the blower elements, however, has been subject to considerable improvement in the past few years. Originally, nozzles of all soot blower units were simply screwed in place. Experience showed that the hot gases were continually attacking the threads and that oxidation at this point was much more rapid than elsewhere, with the result that after the blower elements had been in use but a short time, the nozzles became loose and in the course of time dropped out, thus rendering the blower element ineffective. To overcome this difficulty a method of welding the nozzles in place has been developed and is now in commercial use.

The same trouble which developed with screwed nozzles developed with the screwed plugs which were originally used to close the ends of soot blower elements; that is, the gases attacked the threads with the result that the plugs became loosened and at times blew out. In order to overcome this difficulty, caps were welded on the ends of the blower elements. This construction has however recently been modified and greatly improved by placing a disc of steel inside the blower element, then swaging the end thus partly closing it, and then welding the plug in place, completely closing the end so that there is no possibility of the plug being blown out by the steam.

Probably no feature of soot blower construction has been subject to so much study and improvement as have the bearings which support the units inside the boiler. These bearings were originally made of cast iron, but in the last year a special type of steel bearing has been presented which has innumerable advantages over the old style cast iron bearings. The advantages of the steel bearing are the closer grip on the boiler tube, less transfer of heat, less likelihood of working loose from the boiler tube, etc.

Illustrations to accompany this article furnished by courtesy of the Diamond Power Specialty Company, Detroit, Michigan.

ECONOMICAL FIRING OF STEEL PLANT BOILERS.

(Continued from page 310)

(a) Equivalent evaporation per hr. per sq. ft. of boiler heating surface based on water entering boiler	2.31 lbs.

Capacity Based on Temperature of Feed Water Entering Economizer.

31.	Equivalent evaporation per hour from and at 212 degrees	25,423.7 lbs.
	(a) Boiler horsepower developed	736.9 bhp
32.	Rated capacity per hour from and at 212 degrees	17,940 lbs.
	(a) Rated boiler horsepower	520 bhp
33.	Percentage of rated capacity developed	141.7%

Capacity Based on Temperature of Feed Water Entering Boiler.

34.	Equivalent evaporation per hour from and at 212 degrees	23,350 lbs.
	(a) Boiler horsepower developed	676 bhp
35.	Rated capacity per hour from and at 212 degrees	17,940 lbs.
	(a) Rated boiler horsepower	520 bhp
36.	Percentage of rated capacity developed	130%

Economy of Economizer and Boiler.

37.	Water fed per lb. of coal as fired	8.49 lbs.
38.	Water evaporated per pound of dry coal	9.04 lbs.
39.	Equivalent evaporation per lb. of coal as fired	10.63 lbs.
40.	Equivalent evaporation per lb. of dry coal	11.31 lbs.
41.	Equivalent evaporation per lb. of combustible	13.04 lbs.
42.	Calorific value of 1 lb. of dry coal by calorimeter	12,610 Btu.
43.	Calorific value of 1 lb. of combustible by calorimeter	15,013 Btu.
44.	Efficiency of boiler, economizer and furnace	87.03%
45.	Efficiency based on combustible	84.28%

Economy Based on Temperature of Water Entering Boiler.

46.	Water fed per lb. of coal as fired	8.49 lbs.
47.	Water evaporated per lb. of dry coal	9.04 lbs.
48.	Equivalent evaporation per lb. of coal as fired	9.76 lbs.
49.	Equivalent evaporation per lb. of dry coal	10.36 lbs.
50.	Equivalent evaporation per lb. of combustible	11.95 lbs.
51.	Calorific value of 1 lb. of dry coal by calorimeter	12.610 Btu.
52.	Calorific value of 1 lb. of combustible by calorimeter	15.013 Btu.
53.	Efficiency of boiler and furnace	79.87%
54.	Efficiency based on combustible	77.26%
55.	Proximate	
	(a) Moisture	.94%
	(b) Volatile matter	29.92%
	(c) Fixed carbon	52.56%
	(d) Ash	17.52%
	(e) Sulphur	1.28%

Analysis of Flue Gas.

56.	(a) Carbon Dioxide (CO_2)	8.27%
	(b) Oxygen (O_2)	8.83%
	(c) Carbon monoxide (CO)	.166%
	(d) Nitrogen (N) by difference	82.734%
57.	Analysis of	Combustion Ash Retained
	(a) Moisture	14.7%
	(b) Combustible	0.0%
	(c) Earthly matter	85.3%

Heat Balance Based on One Pound of Combustible.

	Btu.	Per cent
(a) Heat absorbed by the boiler	126.54	84.28
(b) Loss due to evaporation of moisture in coal	12.654	.084
(c) Loss due to heat carried away by steam formed by the burning of hydrogen	556.6	3.7
(d) Loss due to heat carried away in dry flue gases	990	6.59
(e) Loss due to carbon monoxide	143	.952
(f) Loss due to combustible in ash and refuse	0	
(g) Loss due to heating moisture in air	45.1	.30
(h) Loss due to unconsumed hydrogen and hydro-carbons, unaccounted for and radiation	613.0	4.08
(i) Total calorific value of 1 lb. of combustible	15,013	99.98

FOREIGN RELATIONS

THE IRON AND STEEL INDUSTRY IN LUXEMBURG

By Samuel H. Cross,

Acting Commercial Attaché, Brussels, Belgium.

The projected economic convention between Belgium and the Grand Duchy of Luxemburg, against which Belgian metallurgical interests have protested, invites attention to the high development of the iron and steel industry in the Grand Duchy. It possesses five groups of iron and steel producers, controlling 70 blast furnaces, of which 23 are scattered in the Saar Basin, Lorraine, and Belgium, while 47 are located in Luxemburg itself.

Plants in Operation.

The largest of the Luxemburg plants, the Société Anonyme des Aciéries Réunies de Burbach-Eich-Dudelange (United Steel Works Company, familiarly known as the "Arbed," from its initials), which owns large ore deposits in France and Luxemburg, has at Burbach in the Saar Basin one section comprising 8 blast furnaces, of which 3 are in operation; 1 Thomas and 1 Martin converting installation; 14 rolling trains; and some construction shops. At Dudelange it owns six blast furnaces (three in operation), the same converting plant as at Burbach, and in addition a foundry and seven rolling trains. This company also operates at Dommeldange construction shops, a steel foundry, Martin converters, and an electric steel plant with three furnaces; the three blast furnaces at Dommeldange are not fired at present. The "Arbed" likewise runs at Esch-sur-Alzette seven rolling trains, a Thomas converting plant, and three of the six blast furnaces installed there.

The Ougrée Marihaye Company, which is actually a Belgian concern with its center of business at Ougrée, on the Meuse just south of Liége, has a section at Rodange, Luxemburg, with five blast furnaces (four in operation), having an annual production capacity of 125,000 tons, and a Thomas steel plant, as well as foundries and rolling mills. The Ougrée-Marihaye plants secure their ores from the Grand Duchy and French concessions, their resources in this connection totaling 6,516 hectares. The Steinfort Blast Furnace & Steel Mill Co., at Steinfort, now has one of its three blast furnaces operating and is planning the construction of rolling mills and a steel plant; its ores are located in the Esch Basin. It has lately taken over the Rhenish Steel Works, at Duisburg-Meiderich.

The Société Métallurgique des Terres Rouges (Red Earth Metallurgical Company), at Esch-sur-Alzette, has 4 blast furnaces at Audun-le-Tiche (Lorraine), 5 furnaces at Esch-sur-Alzette, and 6 others at Bel-Val, with Thomas converters and 10 rolling trains, having a capacity of 1,000,000 tons of steel annually. None of the furnaces at Esch are operating, but two are fired at Bel-Val and five at Audun. The fifth metallurgical group, that of the Société Anonyme des Haut Fourneaux et Aciéries de Differdange-St. Ingbert Rumelange, familiarly known as the "Hadir," has 3 blast furnaces at Ottange (Lorraine), 3 at Rumelange, and 10 at Differdange, with a steel plant and 8 rolling trains at the last-named division. Four of the furnaces at Differdange are in operation, and one at Ottange.

The proximity of the Luxemburg steel plants to the ore deposits gives them an appreciable advantage over their Belgian competitors, who since the war have not received the preferential freight rates on the Belgian railways which until 1914 placed them in a privileged position. The opposition to the Belgian-Luxemburg economic convention therefore emanates entirely from blast-furnace operators, while the steel plants and rolling mills who purchase their pig iron instead of producing it would welcome lower prices on this commodity.

BELGIAN STEEL PLANTS FORM COMBINE.

Acting Commercial Attaché Cross of Brussels, Belgium, cables under date of March 9 that a number of Belgian steel plants have formed a combination for joint action after recovery from war damages. This combination is formed for the purpose of distributing raw materials and for the sale of finished products and replaces the former Comptoir des Acieries Belges. The following companies compose the organization: Cugree, Marihaye, Cockerill, Providence, Angleur, Hainaut, Thy le Chateau, Althus Grivignee, Esperance Longdoz, Clbecq, Moncheret, Bonehill, Halanzy and Chatelineau.

THE GERMAN METAL BAROMETER INDUSTRY.

By Howard W. Adams,

Representative of the Department of Commerce, Berlin.

At present there are eight plants in Germany engaged in the manufacture of metal barometers. These plants are located in Hamburg, Stuttgart, Berlin, and in Buetzow in Mecklenburg-Schwerin. The number of workmen now employed in this industry is 300.

During the war the demand for the products of this industry was very limited. Upon the cessation of hostilities business began to pick up and continued to improve through 1919, reaching its culmination in an unusually brisk Christmas trade in that year. This industry since the close of the war has been subjected to many handicaps which have caused production to fall far behind that of pre-war years. Among the difficulties encountered have been the lack of raw material, especially metal and glass, strikes and other labor troubles, together with an insufficient supply of electric power, this latter condition at times existing for weeks at a time. As a result of this situation old customers could only partially be supplied, whereas no deliveries whatever could be made to new purchasers.

In the meantime, the prices of metal barometers reached a figure which has been prohibitive so far as the German consumer is concerned. Furthermore, the countries which had been placing big orders for metal thermometers with German manufacturers have for some time been curtailing their purchases. In many cases foreign buyers have canceled their orders.

SLAG AS A ROAD MATERIAL IN INDIA.

Interest is being taken in the use of slag material in India. It is found to be valuable in making tar bound macadam roads, which are taking the place of water bound macadam. It is stated that slag has a special affinity for tar but it must, however, be carefully selected by rejecting all porous material. In view of the fact that the iron and steel industry is commanding greater attention in India, this use of slag is considered timely.

NEWS OF THE PLANTS

The Maryland Steel Rolling Company, Fidelity Building, Baltimore, Md., recently organized with a capital of $200,000, has plans under way for the construction of a new local plant at Eighth and Monument streets, to be used as a steel reclaiming mill and general steel works. The plant will specialize in the production of iron and steel bars of small sizes, produced from high quality scrap. The machinery for the most part will be electrically operated, and the works will include an open hearth furnace. This latter installation will be increased at an early date. The initial plant will have an output of about 15,000 tons of material per year. It is proposed to commence construction at an early date and have the new plant ready for service during the coming summer. J. G. Miller is president of the company; Reuben S. Baldwin, general manager and J. H. Dashield, treasurer.

The Trumbull-Cliffs Iron Company, Warren, O., has construction well under way on a new blast furnace of 600 tons capacity and expects to have the plant ready for service early in the summer. The new furnace is about 20 per cent larger than the customary type of plant and represents an investment of about $3,250,000. The Trumbull-Cliffs Company is owned jointly by the Trumbull Steel Company, Warren, and the Cleveland-Cliffs Iron Company, and practically the entire output of the furnace will be utilized at the plant of the first noted company. This company also has an option to purchase the furnace at the expiration of a certain period of time. Jonathan Warner is president of the Trumbull Steel Company.

The Northwest Iron & Steel Co., Rookery Building, Spokane, Wash., is planning for the construction of a new iron plant at Leadpoint, in the boundary district of Stevens County. The new plant will be used for the production of pig iron and will have an initial capacity of about 25 tons of this material per day. The output will be increased with the installation of additional equipment at an early date. E. C. Owen is superintendent.

The Youngstown Steel Company, Youngstown, O., will defer the erection of its proposed new plant at Warren, O., until a later date. The works were to be used for the manufacture of puddled iron under a new mechanical process perfected by E. L. Ford, president of the company.

The Wheeling Steel Company, Wheeling, W. Va., has arranged a fund of $3,000,000 for the erection of additions to its plant at Steubenville, O., operated by the LaBelle Iron Works, a subsidiary organization. The work will consist of a number of buildings with the installation of considerable new equipment. Details of the project are being arranged.

The Southwest Steel Company, Springfield, Mo., is planning for extensions and improvements in its plant for increased production. New machinery will be installed, including steel converters. Work will be inaugurated at an early date.

The Chapman-Price Steel Company, Indianapolis, Ind., has commenced operations in its new mill, recently completed. It is to be used for the rolling of sheets. Two mills of this kind are now in operation, with production used by the company in connection with the fabricating branch of its business. The installation at the new mill consists of four finishing mills, two roughing mills and two cold mills. The equipment is electrically operated with motor drive. Other machinery includes squaring and bar shears, four combination sheet furnaces, galvanizing equipment and two double annealing furnaces with auxiliary operating equipment. The plant will be developed to a capacity of 25,000 tons of sheets per annum. Niles Chapman is president of the company; L. H. Price, is treasurer and general manager of sales.

The Dominion Steel Corporation and the Nova Scotia Steel & Coal Co., Montreal, Can., are arranging merger plans with the Halifax Shipyards, Halifax, N. S., the combined company to operate under the name of the British Empire Steel Corporation.

The Allegheny Steel Tank Car Company, Warren, Pa., is said to be planning for the immediate rebuilding of the portion of its plant destroyed by fire recently with a loss estimated at about $100,000, including equipment.

The Midland Steel Products Company, 3136 South Canal Street, Chicago, Ill., has awarded a contract to Holton, Seelye & Co., 140 South Dearborn Street, for the erection of a one-story addition to its plant, to be 25 x 125 feet, located at 1752-58 East Seventy-fifth Street, and estimated to cost about $55,000.

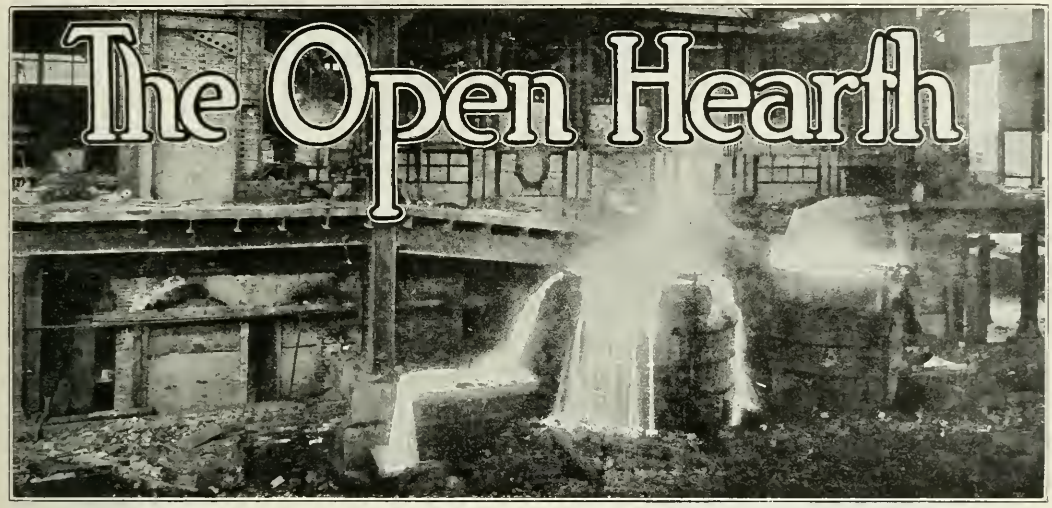
The Willamette Iron & Steel Co., Portland, Ore., has perfected plans for the erection of a new plant on the shipyard site formerly occupied by the Foundation Company. The works will consist of a number of buildings, estimated to cost about $250,000 with machinery. Permits have been taken out to cover the construction of the initial plant units.

The Vulcan Iron & Steel Co., Muncie, Ind., recently organized with a capital of $300,000, has plans under way for the establishment of a local plant for the manufacture of bar iron and steel. Details of the works are being arranged. The plant will operate under a special process perfected by Llewellyn Jones and Charles Westlake, Jr., Youngstown, O. R. Milt Retherford is president of the new company and Walter L. Nelson, treasurer, both of Muncie.

The Erie Crucible Steel Company, East Twelfth Street and Downing Road, Erie, Pa., has taken bids for the erection of an addition to its plant to be equipped as a rolling mill. The extension will be one-story, 60 x 100 feet, and is estimated to cost about $75,000. Frank H. Payne is president.

The Michelman Steel Construction Co., 137 North Second Street, Quincy, Ill., has completed plans for the erection of an addiiton to its plant for increased production, to be 100 x 140 feet, and estimated to cost about $450,000 with machinery.

The Beaumont Iron Works Co., Beaumont, Tex., has plans under way for the erection of an addition to its plant for increased production. It will be one-story, and is estimated to cost about $60,000 with equipment.



The Open Hearth

Mr. George B. Troxell connected with the Bethlehem Steel Company, at Bethlehem, Pa., the past five years has resigned as assistant superintendent of the electric furnace and crucible departments. He is considering a South American project.

√ √

Henry W. Seldon has resigned his position as head of the service department for Amsler-Morton Company and has joined Mr. Theo. S. See in forming the company of See-Seldon & Associates, industrial and combustion engineers, with offices in the Oliver Building. Mr. Seldon is a graduate metallurgical engineer of the Carnegie Institute of Technology and prior to his experience in the glass industry was engaged for ten years in practical engineering and operating work with the Cambria Steel Company at Johnstown, Pa. and the Jones & Laughlin Steel Co. at Pittsburgh, Pa. The new company is engaged in consulting and operating engineering and makes possible for all manufacturing plants a production and efficiency service which has heretofore not been available.

√ √

W. C. Peterson, for the past 12 years in charge of the metallurgical laboratories, heat treating departments and research work, respectively, of the Packard Motor Car Company, Detroit, has resigned to take charge of the metallurgical department of the Atlas Crucible Steel Company at Dunkirk, N. Y., where he will undertake a similar character of work. He is a member of several committees of various national metallurgical and engineering societies.

√ √

Hugh Ferguson of Pittsburgh, has been elected president of the Missouri Iron & Steel Corp., Haigart, Mo., succeeding W. R. Haight of St. Louis, resigned. G. M. Thompson, who has been acting president, was elected vice president and E. J. Shroder of Breese, Ill., was made second vice president.

√ √

E. H. Weitzel, who has been manager of the fuel department of the Colorado Fuel & Iron Co., Denver, for the past 13 years, was appointed general manager of the company March 21, succeeding the late J. B. McKennan. His first coal mining experience was received in the Pittsburgh district. In 1903 his wife's illness forced him to move to the West. He gave up his position as general superintendent of the Empire Coal Company, Bellaire, O., and went to Dawson, N. M., where he took employment as a coal digger. After three years in various capacities he opened an office in Trinidad, Col., and in 1907 was appointed chief engineer of the fuel department of the Colorado Fuel & Iron Co. He was made manager of the department in 1908.

√ √

C. W. Doty, formerly general manager of the Nettleton Steel Treating Company, Cleveland, is head of the Doty Steel Products Company, Los Angeles.

√ √

John W. Mowery, plant engineer Chester Shipbuilding Company, Chester, Pa., has been made general manager of the Worcester Pressed Steel Company. Mr. Mowery is a Cornell man.

√ √

Fred Crolius, steam engineer, Carnegie Steel Company, Homestead, Pa., will deliver a very interesting paper on "Powdered Coal and Its Application to Boilers" on May 14 at the Chatham Hotel. This meeting will be under the auspices of the Combustion Committee of the Association of Iron & Steel Electrical Engineers. Frank Leahy, fuel and experimental engineer of the Carnegie Steel Company, Duquesne, Pa., will act as chairman of the meeting.

√ √

Paul Driscoll, general sales manager of the Penn Seaboard Steel Corporation, Philadelphia, and formerly with the Carnegie Steel Company and the Lackawanna Steel Company in their Philadelphia offices, has resigned. He will become sales representative in New York and Philadelphia for the Niagara Metal Stamping Corporation, Buffalo, of which C. R. Robinson, formerly general manager of sales of the Lackawanna Steel Company, is the head.

√ √

Charles A. Williams, for 25 years connected with the lake trade, has been appointed lake traffic manager for the Jones & Laughlin Steel Co., Pittsburg, and the Interstate Steamship Company, with headquarters in Cleveland.

√ √

George B. Nesbit, chief metallurgical engineer of the

The Open Hearth

Brier Hill Steel Company, Youngstown, O., has resigned to become associated with the International Smelting & Refining Co., Erie, Pa., as production manager.

V V

R. B. Randall has been appointed manager of southwestern territory for the Blaw-Knox Company, Pittsburgh, and has established offices for the company in the Interstate Building, Kansas City, Mo.

V V

Evan F. Jones, who resigned as president and general manager of the Republic Rubber Corporation, Youngstown, O., has reconsidered and decided to remain. Mr. Jones formerly had been president and general manager of the Elyria Iron & Steel Co., Cleveland, and at one time was president and general manager of the Clinton-Wright Wire Company, Worcester, Mass., now part of the Wickwire-Spencer Steel Corporation.

V V

C. F. Blackmer, assistant superintendent American Steel & Wire Co., plant at Waukegan, Ill., has been appointed superintendent of the new wire mill which is being constructed in connection with the Minnesota Steel Company plant at Duluth, Minn. Mr. Blackner will leave Waukegan May 1, to take charge of the construction of the new mill, which will take about a year.

V V

Charles Major, for many years president of the A. & P. Roberts Co., now known as the Pencoyd Iron Works of the American Bridge Company, Pencoyd, Pa., has retired after 41 years continuous service at that plant, and on Saturday evening, March 26, was tendered a testimonial dinner in Philadelphia by his associates. There were also a number of guests. Percival Roberts, Jr., of the board of directors of the United States Steel Corporation and Charles Belsterling of the legal department of the corporation, who was formerly traffic manager of the Pencoyd works, were the principal speakers.

V V

C. E. Dinkey, until a year ago general superintendent of the Edgar Thomson Works of the Carnegie Steel Company, has been made president of the Morrison, Dinkey & Todd Co., a recently organized firm of bond and security brokers, with headquarters in the Diamond Bank Building, Pittsburgh.

John A. Baker, formerly with the Mesta Machine Company, Pittsburgh, as assistant general superintendent, has been appointed works manager for the Los Angeles plant of the Rich Steel Products Company.

V V

G. Conway Shackelford has resigned as consulting engineer of the Republic Iron & Steel Co., Youngstown, O., after serving the company for 14 years. He is succeeded by Stanley M. McKee, his assistant, who assumes the title of chief engineer. Mr. Shackelford will return to his old home in Virginia, where he has purchased a large stock farm and will enter into stock-raising. Prior to his connection with the Republic Company, he served in engineering capacities with the United States Steel Corporation. As chief engineer of the Republic Company, he supervised the plans for the Lansingville plant at Youngstown.

V V

W. W. Runyan, who has been superintendent of operation of the Neville Island Ordnance Storage Depot and who previously was associated with the Whitaker-Glessner Company, both in an operating and a sales capacity at Portsmouth, O., has joined the sales force of Max Solomon, scrap iron and steel, Oliver Building, Pittsburgh. Mr. Runyan was district sales representative of Whitaker-Glessner Company at Atlanta, Ga., and also represented the company in the Southwest, with headquarters at Kansas City, for one year. For the past three years he has been connected with the ordnance department, first with the Pittsburgh district ordnance office and, after the signing of the armistice, with the Pittsburgh district salvage board.

V V

D. W. Pitcock resigned as superintendent of the Masillon Rolling Mill Company on April 6, a position he occupied for seven years.

V V

George W. Reese for 30 years superintendent of the steel foundry of the Lorain Steel Company, Johnstown, Pa., has resigned.

V V

W. C. Bates has severed his connection with the Standard Engineering Works, Ellwood City, Pa., and located in Pittsburgh.

WITH THE EQUIPMENT MANUFACTURERS

COMBINATION PNEUMATIC PUNCH AND RIVETER

A new machine manufactured by the Baird Pneumatic Tool Company of Kansas City, Mo., which can be used either as a punch or riveter simply by changing the dies, has recently been put on the market.

Among the many advantages of this machine is the fact that although it is a stationary unit, it can be readily be moved from place to place in the plant where the work is located as it weighs only 600 pounds complete.

It has a capacity for punching ⅝-inch plate and for riveting ⅜-inch cold rivets and because of this dual use is particularly adaptable for light structural steel fabrication. In a recent test in the plant of one of the largest and most efficient manufacturers in America, this machine with two operators did the work heretofore accomplished by eight men using pneumatic hammers, and did the work better.

The pressure exerted on the punch and rivet dies is approximately 70,000 pounds. It operates on the standard air line pressure of 100 pounds.

BELLEVUE ANNEALING FURNACE.

A late type of annealing furnace developed by the Bellevue Industrial Furnace Company, Detroit, Mich. The furnace is of the semi-muffle type and can be heated by either oil or gas. It is equipped with a hand-operated chain mechanism for raising or lowering the door, the weight of the door being suitably counter-balanced. Two of the company's standard oil-burners are ordinarily used for heating the furnace and are located at the front, where they are easily available for adjustment. The gas burners can be substituted if desired.

The furnace is built in six sizes, the muffles being from 56 to 78 inches wide, 60 to 120 inches deep, and 8 to 24 inches high, the dimensions of the minimum and maximum sizes being given.

QUICK-ACTING STEAM DROP-HAMMER.

A line of quick-acting steam drop-hammers of small sizes has been developed by the Massillon Foundry & Machine Co., Massillon, O., for use on light work. These hammers are built in sizes of 400, 600 and 800 pound capacity, but other sizes can be built to meet special requirements. The hammers can be operated by compressed air in place of steam, if so desired. The housings and base are steel castings and the cylinder is a semi-steel casting. The company has incorporated in these small hammers its design of adjustment for the ram guides that was originally brought out on hammers of larger size, to permit of the ready removal of damaged push-bolts. The guide adjusting screws are threaded through nuts set in open pockets in the side housings.

THE NEW BROWN RECORDING THERMOMETER.

Sixty years' experience in instrument making stands back of this New Brown Recording Thermometer. It is different from any other thermometer manufactured, in that it incorporates the latest constructional advantages such as:

Pen Arm Adjustable—The pen arm is completely adjustable with set screws for "set" and "tension."

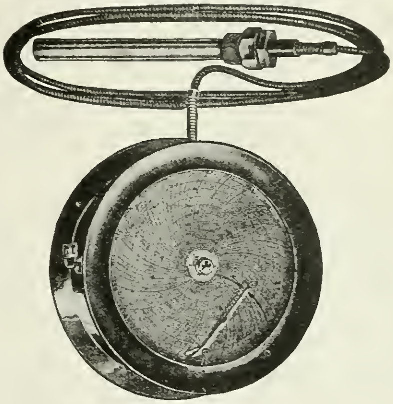
Calibrating Means—The helix is adjustable for calibrating.

Moisture-Proof Case—Every instrument is supplied with a moisture-proof case as standard equipment and at no additional cost.

Automatic Pen Release—Lifts pen automatically when door is opened.

Patented Chart Clips—Automatically lock the chart when the door is closed.

Seth Thomas Clock Eight-Day Movement—Attached to front plate, so that clock must at all times be in alignment with chart, and can be removed, if necessary for cleaning in two minutes.



New Brown Recording Thermometer.

Many charts for ranges from minus 40 degrees F., to plus 1000 degrees F., are carried as standard equipment.

And you will notice from above illustration, the design of this new thermometer, the servicable black enameled case and ring, the open graduations on the chart, the inverted pen arm, the heavy bronze reinforced tubing, the robust bulb, and heavy threaded union connection.

Every detail in the design of this new thermometer has been perfected after years of experience, and a close study of practical conditions. This instrument spells "quality" in every detail. No expense has been spared in manufacture.

For further information regarding this new thermometer, address, The Brown Instrument Company, Wayne Junction, Philadelphia, Pa.

NEW ELECTRIC ANNEALING FURNACE.

The Electric Furnace Construction Company, 908 Chestnut street, Philadelphia, announces an order from the Sociedad Espanola de Construccion Naval, Madrid, Spain, for a new design of electrically heated car type annealing furnace for heat treatment of large steel ingots and forgings. The furnace is stated to be the largest electric furnace in the world for this particular class of work. The dimensions are 6,800 mm long by 4,750 mm wide by 4,140 mm high, and will heat a charge of 60 tons of steel to 1,700 degrees F. every 24 hours. The Electric Furnace Construction Co. has already supplied the same company with an electrically heated furnace 36 feet deep by 12 feet outside diameter for heat treatment of gun and large forgings. The heat regulation on both furnaces is automatic and a predetermined heat of within 5 degrees plus or minus it is claimed can be secured.

TRADE NOTES

The Conveyors Corporation of America, Chicago and New York, take pleasure in announcing the appointment of Mr. Robert B. M. Wilson as sales engineer of the Chicago district. With him will be associated as an assistant, Mr. E. M. Wolfe. Headquarters will be maintained in the corporation's main office at 326 West Madison street.

The sales management for Riley Underfeed Stokers and Murphy Furnaces has been concentrated under one head. Mr. William Pestell, formerly Western sales manager with headquarters at Chicago, now becomes sales manager with headquarters at 1226 Woolworth Building, New York City. Mr. W. L. Bigelow becomes district manager of the Pittsburgh territory, while Mr. C. Lincoln Smith goes to Cincinnati in the same capacity.

To better serve the territory in and around Kansas City, the F. M. Beeson Machinery Company, 308 Mutual Building, Kansas City, Mo., have been appointed sales agents for both Riley stokers and Murphy furnaces. Sales in Denver territory will be handled by Stearns-Roger Manufacturing Company, 1718 California street, Denver, Colo. The Boston, Buffalo, Cleveland, Detroit, Chicago and St. Paul offices remain as heretofore.

Arthur G. McKee & Co., engineers and contractors, Cleveland, have received an order from the Carnegie Steel Company, covering the furnishing of a McKee revolving distributor and new gas seal for their "I" furnace at the Edgar Thomson Works, Braddock, Pa.

Theodore S. See and Henry W. Seldon have organized the firm of See-Seldon and Associates — Industrial and Combustion Engineers and announce the opening of their offices in the Oliver Building, Pittsburgh. Their services are now available as consulting and operating engineers.

At the last meeting of the board of directors of F. J. Ryan & Co., Franklin Trust Building, Philadelphia, specialists in electro-thermic engineering, the following elections to the board of directors took place: Mr. W. W. Posey, president of the Lancaster Iron Works was elected as a director. Mr. A. C. Sculley, secretary and treasurer of the Lancaster Iron Works was elected as a director and treasurer.

The Electric Furnace Company, Alliance, O., has just installed three Baily electric brass melting furnaces of different size and capacity but built upon the same resistance principle. The Bagley & Sewall Co., Watertown, N. Y., has installed a 50 kw electric furnace with 500 pounds hearth capacity, the Alliance Brass & Bronze Co., a 75 kw furnace with 800 pounds capacity, and the Empire Brass Works of London, Ontario, a 106 kw furnace of 1,500 pounds hearth capacity. All of these furnaces are to melt yellow and red brass alloys. The Empire Brass Works is the fourth Canadian plant to adopt the Baily electric furnace for melting its non-ferrous metals.

The Lorain Steel Company, Johnstown, Pa., is installing a 200 kw Baily electric furnace for heat treating railroad bolts and similar parts. The furnace is of the continuous pusher type with motor operated control mechanism. It will have a capacity sufficient to heat treat 14 tons of material per day. Installations of electric heat treating furnaces are rapidly increasing in plants which supply the railroads with equipment. Baily electric furnaces are being employed to treat such products as railway axles, draw bar knuckles, bolts and similar castings and parts.

Victor T. Goggin, late New England sales manager of Fred T. Ley & Co., Inc. of Springfield, Boston and New York, has severed his connection with that concern to associate himself as contracting engineer with Dwight P. Robinson & Co., Inc. of New York, Chicago, Dallas, Youngstown, Los Angeles and Montreal.

Mr. Russell B. Reid, for several years past with Edw. R. Ladew Company, as assistant sales manager, has been made manager of sales for the Sharon Pressed Steel Company of Sharon, Pa., manufacturers of motor car frames, industrial trucks and pressed steel automobile parts. Mr. Reid will direct the sales of the company from the New York office at 66 Broadway.

Mr. C. F. Herington, who has been connected for the past five years with the Bonnot Company, as mechanical engineer and district sales manager in Chicago, is resigning May 1, to accept a position as vice president of the Holbeck Engineering Company, Cleveland, Ohio.

Effective March 1, 1921, the name of Locomotive Superheater Company has been changed to The Superheater Company.

TRADE PUBLICATIONS

The fourteenth annual edition of "Metal Statistics" just issued, contains the same general assortment of statistical information concerning ferrous and non-ferrous metals that has been supplied in previous years, but various new tables have been introduced which it is hoped will further increase its usefulness to the trade. The aim each year is to furnish statistics which provide the information most generally required by the buyers of metals and iron and steel products. The book is for sale by the American Metal Market and the price is one dollar.

"Are Mechanical Stokers a Good Investment?" is the title of a recent publication of the American Engineering Company. It dwells at length on the investment side of the stoker proposition and is full of authenic and definite facts.

"The Open Hearth," a book full of steel plant design and operation has been issued by the Wellman-Seaver-Morgan Company. It covers data obtained by this company throughout its entire existence. It is decidedly the foremost steel plant book of the year. It is to be sold for six dollars per copy.

"Lillie Evaporators for Waste Waters and Solutions Generally," is the subject of Bulletin 114 published by the Wheeler Condenser & Engineering Co., Carteret, N. J., manufacturers of the Lillie Evaporators. In it are described in considerable detail the features peculiar to the Lillie Evaporator and several installations for sugar work, distilling water, and for evaporating many kinds of chemicals, solutions and waste waters. A perspective diagram is also given of the triple-effect and auxiliaries recently installed at the power station of the Chile Exploration Company, Tocopilla, Chile. A free copy of this bulletin will be sent to responsible persons upon mentioning this publication.

The Hercules Powder Company are responsible for a very interesting book entitled "Modern Road Building and Maintenance." It is prepared for the use of engineers, contractors, road officials, students and all who are interested in the national and economic solution of the many problems connected with our public roads and the traffic they are required to carry. It is edited by Andrew T. Anderson, highway engineer, bureau of public roads, U. S. Department of Agriculture. It would be of especial interest to all steel companies where it is necessary to build roads.

An up-to-date Technical Book Review Index dated December, 1920, has just been issued by the Technology Department of the Carnegie Library of Pittsburg. This index is a record of certain book reviews appearing in technical and trade journal. The price of the index is fifty cents.

An interesting booklet on "Transportation, the Problem of Soft Coal" has been issued by the National Coal Association. It was published in an endeavor to obtain even distribution of output so the railroads will not be jammed under strain demand.

A reprint of H. D. Savage's paper on "Powdered Coal Application to Four 2,640 hp Boilers," which was presented before the mechanical section of the Engineers Society of Western Pennsylvania has been issued by the Combustion Engineering Corporation.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., JUNE, 1921 No. 6

American Iron and Steel Institute Meeting

Fifteen Hundred Steel Men Attend the Nineteenth General Meeting — Valuable Technical Papers Read — Judge Gary's Address Features the Meeting.

THE nineteenth general meeting of the American Iron and Steel Institute was held at the Commodore Hotel, New York, on May 27. There were three sessions. The forenoonand afternoon session being devoted to the address of Judge Gary and the reading of a number of the technical papers. In the evening a banquet was held. The technical program presented at this meeting was very interesting. The papers read were as follows:

Address of the President—
Elbert H. Gary, Chairman,
United States Steel Corporation, New York.
The Development of a Commercially Pure Iron in the Open-Hearth Furnace—
W. J. Beck, Director Research Division,
The American Rolling Mill Co., Middletown, Ohio.
Educational Work in the Wire Industry—
Charles R. Sturdevant, Educational Director,
American Steel & Wire Co., Cleveland, Ohio.
Stainless Steel—
Elwood Haynes, President,
Haynes Stellite Co., Kokomo, Ind.
Molybdenum—
Arthur H. Hunter, President,
Atlas Crucible Steel Company, Dunkirk New York.
Recent Developments in Steel Works Power Plants—
W. N. Flanagan Steam Engineer, Ohio Works,
Carnegie Steel Company, Youngstown, Ohio.
The Use of Powdered Fuel Under Steam Boilers—
Harlow D. Savage,
Combustion Engineering Corp., New York.
Dry Cleaning of Coal by Means of Tables—
Edward O'Toole, General Superintendent,
United States Coal and Coke Company, Gary, W. Va.

Part of the papers which were read are contained in this issue of THE BLAST FURNACE AND STEEL PLANT. Others will appear next month.

Judge Gary in his annual address stated that conditions are slowly improving.

"General business throughout the United States has been slowly improving," he said. "It is very good in some of the Western States. I am not at all discouraged."

Economy is the one word that summarizes or is the keynote of quick recovery of business, said Charles M. Schwab, chairman of the board of the Bethlehem Steel Company, in discussing Mr. Gary's topic. There must be economy in labor, and above all else in transportation costs, Mr. Schwab declared, and urged that the institute should make its force felt in securing reduction in transportation costs.

Due to the war and the three years of drifting and struggling which has followed the armistice, business in this country has reached its present state, Mr. Gary said.

"In the richest of nations, in property and money, with the greatest and most rapidly increasing resources, our people are not buying enough to supply themselves fully with the ordinary comforts of life, although they have the disposition and the means to d oso. They are, to an appreciable extent, wearing their old clothing, living in their unrepaired houses, eating unusually plain food, and, in various ways, denying themselves many of the things they would generally buy and utilize. This is in accordance with the inexorable law of supply and demand. The demand is, and for some time has been, below normal."

The reason for this condition, Mr. Gary stated, is that "the great purchasing public has formed the opinion that there have not been consummated complete and proper readjustments of prices; and on account of failure to discriminate between different lines or departments of business the whole economic system has suffered."

Some Prices Extortinate.

In certain lines and for certain commodities Mr. Gary believes that the prices which are still charged are "unreasonable and unfair, if not extortionate."

"The present offenders," he said, "generally speaking, were not subject to limitations by the Government during the war and they have continued and even increased the high prices then obtained. They have done themselves especially a great injury and in doing so have injured others. Retail prices, especially, for many commodities are much too high. Without justification workmen have been classified and reclassified so as to designate them as skilled men. We have heard of persons whose daily wage was advanced from $3 to $10 or $12 at one time under this practice."

The vast majority of workmen and business men Mr. Gary believes to be fair and honest.

"There is, however," he said, "a minority that ignores the principles of common honesty. These are sufficient in numbers to seriously affect the whole situation. Until they are aroused to the necessity of getting in line with sound and decent standards of conduct, the full return to satisfactory business conditions will be more or less impeded.

"All that I have ever said during or since the war concerning a return to great prosperity in this country has been predicated on business managed in accordance with the principles of reason, fairness and honesty."

"If laws shall be enforced and peace maintained, the other questions relating to economic progress and achievement will be solved. The law of supply and demand will steadily, if gradually, bring about necessary adjustments which are equitable and relative and restore levels which are natural and reasonable. Business will be more or less hesitating until it is generally believed that the period of readjustments is over.

Mr. Gary further stated that if it seemed wise and in the direction of public benefit that the Government should supervise organized industry he would not object, "provided that the laws and rules shall apply alike to organized capital and organized labor."

In regard to the steel industry in particular, Mr. Gary said that he was not prepared at the present time to express an opinion as to how normal conditions might be restored. In regard to wages he declared, however, that it was his belief that there should be no further reductions until at or near the time selling prices are lowered.

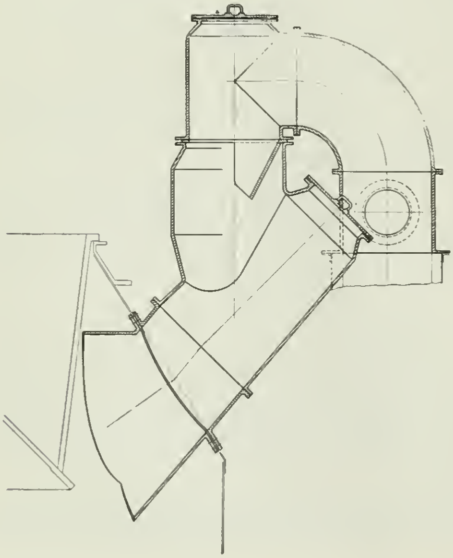
"There is an abundance of new business," Mr. Gary said in conclusion, "with both the ability and inclination to place it, waiting for further adjustments which will put costs of living, selling prices, wage rates, and other general incomes on a relative parity. As usual, many will wait too long. There is nothing the matter with the country; it is the individuals. Patience, courage, and a fair disposition will bring satisfactory conditions in due time."

NEW TYPE OF DOWNCOMERS.

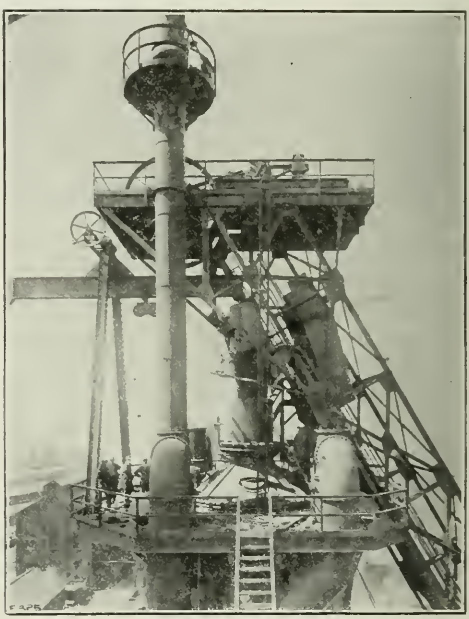
It is always interesting to know about new departures from common practice when they really accomplish something worth while.

One notable departure of this sort is the new type of downcomer which has recently been patented by Arthur G. McKee & Co., Cleveland, O., and installed by them on a number of blast furnaces throughout the country.

All blast furnace men are of course familiar with the high downcomers which have been constructed in the hope of reducing the amount of stock thrown out of the furnace, especially during slips. These have been quite successful in that they certainly have made a decided reduction in the amount of material lost to the dust-catcher, but they have two distinct disadvantages, namely, they are expensive to construct, and they are very heavy and cause an undue obstruction of the space on the furnace top, running up as they do to the top of the top structure with four large pipes and with two additional pipes coming down again. At the same time, they have no real provision for separating the stock from the gas, except the fact that it must travel a greater distance upward.



The McKee device, which is shown on the adjacent photograph and drawing, is quite simple. It is very low and compact as compared to the high pipes, and it does have a definite and efficient means for separating the stock from the gas and returning it to the furnace.



As shown on the above drawing, the gas and particles of stock travel initially in the direction of the inclined outlet from the furnace. The gas must turn, however, at a sharp angle from this direction in order to enter the vertical branch from this pipe and pass the baffle which is provided as shown.

The trajectory of the particles of stock is inclined to fall below the direction of the inclined outlet, and in order to get into the vertical pipe and pass the baffle, it must be diverted sharply upward from its initial direction. The only influence tending to divert it is the flow of gas, and it has been fully demonstrated that, except for the very small particles, this does not happen, and all but the very small particles go past the outlet, strike the end of the inclined pipe and roll back into the furnace.

These downcomers have been in use on several furnaces and have accomplished in an efficient manner the results which have been sought in the construction of high type downcomers.

The Development of Commercially Pure Iron in the Basic Open Hearth Furnace

Experiments Carried On by the American Rolling Mill Company in the Manufacture of Pure Iron by the Open Hearth Process—Important Uses of Ingot Iron.

By W. J. BECK,*
Director of Research, American Rolling Mill Co.

THE first announcement before a scientific and technical body that the manufacture of commercially pure iron had been successfully accomplished in the open-hearth furnace was in a paper which was read at a meeting of the American Society for Testing Materials in 1911.† The following significant paragraphs which remain equally true today are worthy of repetition:

> The industrial history of the country has been characterized during the last ten years by so many important changes and developments that, taken as a whole, they may well be considered as marking a new industrial epoch. These changes may be defined in part as social and political, and in part as purely technical evolution. Thus we find extraordinary change and activity following in the wake of the great movements for conservation of natural resources and government control of the quality of foods, drugs, and other staples which enter into interstate commerce. The day when a complacent public would buy any material offered for sale, with little or no regard for specification and with implicit faith in every word printed on a label, has probably passed, never to return. Quantity rather than quality has heretofore marked the industrial supremacy of the United States, but the signs of the times point to the fact that hereafter the maximum quantity consistent with a standard of quality will be the slogan of the progressive producer.
>
> Europe has long been looked upon as the home of research and conservation, and it is only comparatively recently that America has been brought to a thorough realization of the necessity of re-ordering her ways if she is to take her place in the upbuilding of the industrial future of mankind. It is satisfactory to note that the wave of conservation is sweeping along all the lines of industry, and the ruthless waste formerly so common in manufacturing methods is rapidly disappearing. Almost all new countries, especially if bountifully supplied with natural resources, have had this experience. It is the natural result of rapid growth which leads to a disinclination to consider apparently minor details until forced to do so by stern necessity. The movement for the conservation of our forest products, which is comparatively new in this country, is old and well-known in Germany, and it is now very generally conceded that this country has taken up the study of the conservation problem none too soon. It is but natural in this great wave of economy the conservation of iron should have become such an all-absorbing subject. There can be no question but that this important commodity is directly and indirectly the greatest force for civilization that exists.

It cannot be questioned that there has always existed a demand for the purest obtainable irons. This demand has held steadfastly in the face of rapidly developing steel producing processes. The steady importation of Norway and Swedish irons throughout our entire metallurgical history up to the outbreak of the war in 1914 is sufficiently indicative of this fact. These foreign irons, however, that had to be laboriously worked down by a charcoal or puddling process, were not suited to the large-scale tonnage operations which are made imperative by American conditions of labor and industry. It is natural, therefore, that our metallurgists should have been led to the consideration of adapting the open-hearth steel furnace to the manufacture of iron of at least an equal degree of purity as those types which were imported from overseas.

Before progress along this line could be made, however, grave manufacturing risks had to be faced without much foreknowledge as to whether a successful, workable and salable product could be finally achieved. Every open-hearth man knows what is implied in raising the temperature of a bath two hundred degrees above the normal practice and maintaining this temperature until the carbon and manganese are run down to practical traces.

Development of the Process.

The undertaking of pioneer work in this direction was certainly not altogether promising. Ledebur, the great German authority, had clearly stated in his compendious work on iron metallurgy that any such operation with the open-hearth furnace would be in vain if not freighted with disaster. In 1903, however, a very distinguished Amercian metallurgist, H. H. Campbell,‡ made an attempt at an open-hearth pure iron, and finished with carbon .025, manganese .040. Campbell did not follow up this step, however, and summed up his opinions in the following brief comment: "These heats were made in a basic open-hearth furnace and their regularity both in chemical and physical character shows that we are dealing with a normal and definite metal and not with an accidental product. They were purposely made with the lowest possible content of manganese and it seems positively certain that the metal must be saturated with oxygen." It is evident from the foregoing that so eminent an open-hearth man as Campbell thought that in carrying manganese down to .04 the procedure had gone as far as possible and that only an overburned metal was the result.

This then was the history of the effort to produce very low carbon-manganese metal in the open-hearth furnace when The American Rolling Mill Company first turned its earnest attention to the problem. The very first experimental heats were made in a 35-ton furnace, and they were nursed and watched with the most anxious care day and night. Continuous progress in the art was made until finally it was proved possible to reduce the five ordinary impurities of iron (carbon, manganese, sulphur, phosphorus and silicon) to the point at which in the aggregate they did not exceed fourteen-hundredths of one per cent. At the same time special methods had to be studied to attain the maximum degree of degasification and the proper deoxidization.

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*Paper read before the American Iron & Steel Institute, at New York, May 27, 1921.

†The Manufacture of Pure Irons in Open-Hearth Furnaces, A. S. Cushman, Proceedings, American Society for Testing Materials, Vol. XI, 1911.

‡The Manufacture and Properties of Iron and Steel (1904), p. 482.

The idea of a commercially pure iron was perhaps but a natural development or evolution of the effort to supply quality sheet metal products. It was believed at the inception of this work that increased purity would lead to increased rust-resistance.

Ingot iron made in an open-hearth furnace differs from the older irons in having a typical crystalline structure, a more definite critical temperature range, and more particularly in being essentially free from slag.

In the first heat an attempt was made to produce a metal containing not over .05 per cent. manganese. It was done at the risk of losing the heat and the ladle, but it was felt that such a drastic step was necessary in order to determine if it were possible to make such a product in an open-hearth furnace. Care was used in the selection of the raw materials for this heat so that the melt would be as low as possible in carbon and manganese. The heat was charged in a 35-ton furnace and the bath of metal melted low in carbon, as it was believed that the lower the carbon could be driven the lower would be the manganese. Regular open-hearth practice was followed with the exception that an additional quantity of iron ore was added to assist in the removal of the carbon and manganese. In addition to this an excess amount of lime was charged for the purpose of eliminating as much sulphur and phosphorus as possible.

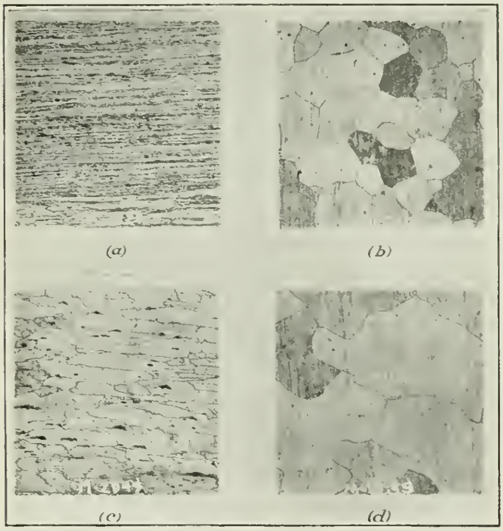

Fig. 1—Microphotographs of Armco ingot iron, X 100. (a) Unannealed, (b) properly annealed, (c) under annealed, (d) over annealed.

These early experiments in the open-hearth furnace were made with producer gas as fuel. This fuel was high in sulphur which contaminated the metal and presented a serious obstacle. It was later found that by the use of natural gas this difficulty was largely overcome and it was possible to produce a metal which contained a lower percentage of sulphur.

In order to eliminate as far as possible the impurities in these heats it was found necessary to hold the metal in the furnace longer than is required in ordinary steel practice. In some cases these experimental heats were held in the furnace as much as 50 per cent. longer than the ordinary steel heat, with danger to the operators and to the furnace.

On tapping the first iron heat into the ladle it was "wild." The normal amount of aluminum customary in making steel heats had been used, but in later developments it was found necessary to increase materially the amount of aluminum, to insure proper deoxidation and degasification.

In the early development of this iron it was made on a small plant basis, using bottom-pour ingots approximately 8" x 10" cross section and weighing about 900 pounds. In this bottom-pour practice it was necessary to line with fire-clay runner brick the runners which conducted the metal to the ingot molds.

In pouring the first heat the metal was so hot that the stopper rod burned off and there was much difficulty in pouring the metal. The molds were smeared and much of the metal was lost by pouring into the mold pits. Considerable cutting of the runner and ladle lining also occurred.

The ingots were stripped in the usual manner and sent to the reheating furnace for rolling into sheet bars. Here they were rolled into heavy gauge bars without difficulty, and later rolled into 16-gauge sheets and sheared to size for galvanizing.

As the next step in the operation the sheets were sent to the galvanizing shop for coating. Here considerable difficulty was found in pickling the sheets on account of the slow solubility of the metal, and also on account of the presence of foreign matter such as fire-clay from the runner brick and ladle linings. In galvanizing the sheets, further difficulty was encountered in the development of blisters and rough surfaces, which were afterward found to be due to imperfect degasification of the metal.

The analysis of this first heat of ingot iron was: Si trace, C .028, P .003, C .03, Mn .04. At that time it was customary to analyze only for these five elements—silicon, sulphur, phosphorus, carbon and manganese—the aggregate of these being subtracted from one hundred, which was the basis then used, indicated the iron content by difference.

Several years were required to develop the material, even to the point of making this first heat, and for this reason the final and successful result was the occasion for much congratulation among the workers. A new metal with many unusual properties had been given to the world.

Degasification and High Temperatures.

In the manufacture of such pure metal the process of degasification was not understood. It naturally followed that a large number of sheets were produced which contained imprisoned gases. When such sheets were galvanized the expansion of the imprisoned gases caused the formation of blisters up to 12 inches in diameter, giving a product which could not be sold even as wasters, and of doubtful value as scrap. This trouble resulted in a further search for a method to eliminate the gases which were responsible for the blisters. Green saplings were used by plunging them down into the bath of metal in the open-hearth furnace after the heat was melted, in an effort to agitate the metal to help remove the impurities. This slightly reduced the time of finishing the heat, but nothing could be found to substitute for the extremely high temperatures necessary to reach the desired analysis of the metal.

These destructive temperatures shortened the life of the furnaces and very greatly increased the cost of the metal. In fact, it was impossible to make this metal continuously in the furnace because of the cutting action on the linings due to the high iron oxide in the slag. To meet this condition heats of pure iron were alternated with regular steel heats.

The experimental heats of iron produced many unusual and unlooked-for results. One of these heats contained so much gas that nothing but piped ingots were made. In fact, some ingots were piped from end to end with only a thin wall. These had the shape of the molds and weighed but a few pounds, whereas they should have weighed approximately 900 pounds. It was an easy matter for a workman to carry one of these shell-like ingots on his shoulder as a spectacular "stunt" for his fellow-workers.

Special efforts to secure iron of extreme purity were continued in the open-hearth department during the years 1906 and 1907. Every effort was made to produce a material of high purity. All practical suggestions (and many that were apparently impracticable) were tried. The principal difficulties, however, remained; that of the control of high temperatures necessary in producing this iron and the proper degasification of the metal.

As the experimental work progressed it was found that there were considerable differences in the practice of producing commercially pure iron as compared to steel practice, which materially added to the cost. In the first place, it required several hours longer to make an iron heat than a steel heat, and the final temperature of the metal was 200 degrees Fahrenheit higher than a heat of steel. Another marked difference was also found between the percentage yield of metal as compared with the percentage yield when steel was made. The percentage of metal produced was several per cent lower in the iron heats because the high temperatures and longer time employed in the manufacture of iron oxidized more of the iron, which was lost in the slag.

It was also found that this high iron oxide content of the slag was responsible for the cutting action on the stopper rods and bricks, and that the scorifying action increased as the percentage of iron oxide in the slag increased. It has been found that the iron oxide in this slag is several times greater than the iron oxide in the steel slag. Some of this iron oxide, however, is derived from the iron ore used in oxidizing the carbon and manganese.

In order to emphasize the importance of the selection of raw materials in the manufacture of commercially pure iron, attention is called to the fact that there are certain elements which if they exist in the raw material are not eliminated in the open-hearth furnace. Among these elements which cannot be eliminated are copper, arsenic, antimony, tin, nickel and cobalt.

The Critical Temperature Range.

Early ingots were frequently split with a metal saw so that the interior structure and the degree of degasification could be studied. It was found that ingots degasified with a slight excess of either silicon, aluminum or even with the use of a small amount of ferro-manganese, may be perfectly sound as far as gas pockets determine this factor. Nevertheless, such material will go to pieces when an attempt is made to roll it.

This breaking up of material degasified with an excess of degasifying agents led to the discovery of the fact that pure iron had to be worked within a certain range of temperature; otherwise, it was found to be red-short and could not be rolled. It was also found that not only was the rolling of commercially pure iron affected by the presence of impurities from the degasifying agents, but it was materially affected by the presence of sulphur. The higher the sulphur content the more difficult it is to roll this iron at any working temperature. Being almost pure, this iron has, like many commercially pure metals, a critical range at which temperature it cannot be worked. This temperature is about 900 degrees C., but for working conditions it is impracticable to roll at temperatures between 800 degrees and 1000 degrees C. In the commercial manufacture of this pure iron it is necessary to roll the material above the critical range on the blooming mill and below the critical range on the bar mill, which necessitates cooling tables between the two mills, these cooling tables being unnecessary in steel practice.

Because of the tendency of the sheets to weld together at the higher temperatures the sheet bars also must be rolled on the sheet mills at much lower temperatures than employed in rolling steel sheet bars.

The use of the microscope plays a very important part in the final treatment of these commercially pure iron sheets, and special care is necessary in the annealing of the sheets in order that they may serve the purpose for which they are intended. Microphotographs of a sheet as rolled on the sheet mill show, first (see Fig. 1a) the elongated grains and then after proper annealing (see Fig. 1b) the rounded grain structure.

The microphotographs shown in Figs. 1c and d illustrate very clearly the effect of improper annealing upon the structure of the metal. The elongated grains of a sheet annealed near the bottom of the box (Fig. 1c) are due to either insufficient time or to low temperature. The coarse grains, free from strains, of the other microphotograph (Fig. 1d) illustrate the grain growth caused by annealing at too high a temperature.

Important Uses of Ingot Iron.

Having developed an open-hearth pure iron primarily for its rust-resisting properties, we were gratified to find upon further study that it had many other interesting and valuable qualities, which taken together make a metal for more general use than had been attained by any other ferrous sheet metal product.

The high purity of the metal finally attained is shown by the following average analysis: Si trace, S .035, P .005, C .013, Mn .021.

We have found that this pure iron galvanizes in a superior manner to steel. Exhaustive tests have shown that when various grades of steel are galvanized in the same pot and under exactly the same conditions as when galvanizing this pure iron, not only will the pure iron take on a heavier coating, but this heavier coating will have less tendency to peel when the metal is fabricated.

We have learned that pure iron goes into solution in molten spelter more slowly than steel; and we have learned that pure iron flux boxes and gears which are immersed in molten spelter will outlast many times similar equipment made from steel. It has been determined by analysis that the iron content of the spelter on steel will average much higher than the iron content of the spelter on pure iron. This is attributed to the greater density and better degasification of the iron.

Believing that a ferrous metal of such high purity meant rust-resisting properties, we began the study of its behavior under general service conditions. For twelve years the metal has been tested under a great many laboratory and service conditions and the results which have been obtained indicate that it is suitable for many exacting needs where ordinary steel has not proved satisfactory.

The purity of this product and the careful methods used in its manufacture make it more homogeneous than steel, and it therefore flows uniformly when heated to a melting temperature. This characteristic led to its use for many purposes where the cost or efficiency of welded articles depended upon quality of the weld or ease of welding operations. The welding quality of commercially pure iron created a demand for this material in the form of welding wire and rods to such an extent that conversion arrangements were made for the manufacture of large quantities of commercially pure iron welding rods and wire. This material has already largely displaced the welding materials of foreign manufacture previously used in this country. Welding wire made from this metal is used for electric arc welding and gas welding. This iron when drawn into wire has a very low electrical resistance for a ferrous metal. Its conductivity is approximately 50 per cent. greater than soft steel, or about 18 per cent. of the conductivity of copper.

Another important use of this commercially pure iron lies in its excellent vitreous enameling properties. In the degasification of the metal in the open-hearth process the detrimental gases are practically eliminated. Enameled products made from this iron have a superior finish and are free from blisters, pinholes and other enameling defects.

The average analysis compiled from records covering a period of twelve months gives this iron a purity of 99.865 per cent. This takes into consideration the nine impurities—silicon, sulphur, phosphorus, carbon, manganese, copper, oxygen, hydrogen and nitrogen.

In addition to almost 200,000 tons of ingots which we produced in this country during the past year, pure iron made in the open-hearth furnace is being produced abroad and used extensively in Norway and Sweden.

The manufacture of pure iron in an open-hearth furnace may be witnessed by members of the Institute and their friends at any time.

The Manufacture of Stainless Steel

Discussion of the Chemical Properties, Influence of Temperature, Physical Properties and Uses of Stainless Steel.

By ELWOOD HAYNES,*
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THE name "steel" has now such a broad application that it conveys quite a variety of impressions, according to what one may have in mind. To the builder of skyscrapers it means monstrous I-beams and other heavy parts used in the construction of great buildings. To the railway builder it may convey the idea of rails or bars for construction of track, while to the general dealer in bar iron it may mean numerous round and flat shapes such as are demanded by the general trade. To the metallurgist it may not only mean all of these, but include also the various alloys of iron with other metals, commonly termed "alloy steels."

Among these are nickel steel, nickel-chrome steel, vanadium steel, tungsten steel, molybdenum steel, titanium steel, silicon steel, manganese steel, etc. Besides the above there are many combinations of these alloys, many of which have highly useful properties. All of the above, however, are to some degree subject to rust or corrosion when exposed to moist air.

With the discovery and manipulation of high-chrome steels, an alloy has been revealed and manufactured which resists corrosion to a most remarkable degree, and which is now termed "stainless steel." Such a steel must contain iron, chromium and carbon, and may contain various other elements, such as manganese, molybdenum, tungsten, silicon, etc. Moreover, such a steel does not become distinctly immune to atmospheric influences until the chromium reaches at least 8 per cent and only exhibits its highest quality when the alloy contains 11 or 12 per cent. Most of the combinations thus far in use contain from 12 to 20 per cent chromium as an essential constituent. An alloy of chromium with iron and carbon, containing as high as 60 per cent chromium, may be worked to some degree under the hammer if extreme care is used in its manipulation.

If steels of this character be freed from adhering scale or rust, they will resist atmospheric influences to a most marked degree, far excelling in this respect such metals as tin, nickel, lead, cobalt, copper, silver, etc., and such alloys as brass, German silver, Monel metal, etc.

For most purposes the carbon content of these steels should lie between four-tenths per cent and eight-tenths per cent, while steels of considerably higher carbon may be utilized with advantage for special purposes.

The manufacture of these steels is comparatively simple, though the best results are obtained by means of the crucible or electric furnace. Those made by melting the steel in lined graphite crucibles, when proper precautions are taken, may be teemed into ingot molds, and show even less oxidation during pouring than the ordinary carbon steels. If the ingots thus produced are of small size, and hence readily chilled, they are usually quite hard when taken from the mold and require annealing before they can be worked on the lathe.

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*Paper read before the American Iron and Steel Institute, at New York, May 27, 1921.

If small flat bars are heated to about 1500 to 1800 degrees F., and allowed to cool in the air, they will become hardened to a very considerable degree, and for many purposes no further hardening will be necessary. If, on the other hand, extreme hardness is desired, the article may be quenched in oil or water.

After the ingot is removed from the mold it is placed in a clear fire (in which coke, oil, or gas may be used as fuel), and brought to a temperature of from 1500 to 1800 degrees F., it may then be readily forged or rolled into bars. When properly heat treated it becomes highly elastic, and may be given almost any desired hardness by drawing at the proper heat. It shows practically no scale during the hammering process, and this fact largely compensates for the increased hardness of the hot metal over that of ordinary carbon steel. It may also be drop-forged under suitable dies, though it of course offers greater resistance, and hence greater wear and tear on the dies.

Chemical Properties.

As already stated, the chromium content of a stainless steel should be at least 12 per cent, and may rise as high as 25 per cent without seriously interfering with the workability of the steel, providing proper care is exercised. All things considered, a very good stainless steel may be made containing, say 15 to 18 per cent chromium, with carbon ranging up as high as eight-tenths per cent.

When such a steel is rolled or hammered into a bar and afterwards heat treated and polished, it shows remarkable resistance to atmospheric influences. It may be exposed for months in a moist atmosphere, even in the vicinity of the ocean, without showing any sign of stain whatever. It may be immersed in salt water and remain indefinitely without change. It may be even boiled in nitric acid without losing its luster. It may likewise be dipped in a solution of sal ammoniac (ammonium chloride) and afterward exposed without washing to the atmosphere for an indefinite time without change. It is likewise immune to vinegar or mixtures of salt and vinegar, as well as to the action of citric acid. If the chromium be raised to 40 per cent or over and a small amount of molybdenum added, the steel will resist boiling solutions of salt and citric acid, even in the concentrated form.

Influence of Temperature.

When a polished strip is heated in a Bunsen flame, it first takes on a pale straw color, then pale brown, gradually passing into a bright blue, and finally culminating in a deep blue-black. Samples containing a suitable quantity of chromium may be held at a temperature of 800 to 1000 degrees C. for an indefinite time without showing any tendency to scale. The steel is much more rigid under high temperature than the ordinary carbon steels, and articles exposed to high temperatures would hence retain their shape much better under stress.

Physical Properties.

As already stated, the steel may be forged at temperatures varying from 800 to 1200 degrees C. and may be readily rolled into rods and sheets under proper conditions.

By proper annealing, a bar of 15 per cent chrome steel can be rendered sufficiently soft to be worked in the lathe, though even when annealed it is much harder than ordinary machinery steel.

When thin strips are heated and allowed to cool in the air, they become almost file hard; and even ingots cast in thin flats in a graphite or steel mold are almost file hard even when allowed to cool in the air.

The steel yields to heat treatment quite readily, though its recalescence points are generally higher, and the steel does not respond so quickly to treatment as do the ordinary carbon steels. Complete data under various heat treatments is lacking, but the following may be taken as fairly representative—elastic limit, 115,000; tensile strength, 200,000; elongation, 2½ per cent; scleroscope hardness, 80.

It will be noted that the elongation of the heat-treated steel of this character is rather low, but on the other hand, it is distinctly perceptible. It will be further noted that the ultimate breaking stress is considerably above the elastic limit, which indicates also that the steel is much tougher than a carbon steel of the same hardness.

Uses of Stainless Steel.

The peculiar properties of stainless steel suggests its use for a great variety of purposes, such a pans, kettles, knives, forks, hatchets, axes, saws, chisels, etc. Indeed, all these utensils and instruments have been made from stainless steel with very good results. The alloy will also doubtless find larger use in the form of pump shafts, driving shafts, ships' propellers, etc. Its high modulus of elasticity and high tensile strength as compared with bronze especially recommend it for these latter uses. Its resistance to comparatively high temperatures, together with its tendency to retain its form, will doubtless render it of great service in the form of retorts for various operations such as gas making, shale distillation, and various other uses.

Owing to the comparatively high percentage of chromium, the cost of the steel will always be more than that of the straight carbon steels, but even so, it will doubtless find wide economic use because of its permanence and reliability under most trying conditions. Its application to concrete work which is exposed to salt water also suggests an important application of the steel.

NEW STEEL MILL FOR BRAZIL.

The Brazilian Official Gazette has published a decree authorizing the Federal Minister of Agriculture, Industry, and Commerce of Brazil to enter into a contract with a local company for the construction of a steel mill equipped with electric furnaces. The importation of necessary materials, such as machines, motors, furnaces, etc., will be duty free for a period of 30 years. Permission is granted the company for the use of waterfalls belonging to the Federal Government.

CHARCOAL REPLACING COKE IN MANUFACTURE OF IRON.

At Vordernberg, the oldest iron manufacturing plant in Austria, furnaces using wood charcoal were operated for over 600 years until three years ago, when they shut down, being supplanted by the larger furnaces using coke as fuel at Donawitz. Now, in consequence of the difficulty o fsecuring coke, work has been resumed at one furnace which produces five carloads of crude iron per day, at about the same cost of production as with coke.

Modern Steel Works Power Plant

In These Days When Economical Production Is Such a Main Issue In Manufacture of Steel, Power Plants Offer Such Possibilities of Saving That They Must Be Carefully Considered.

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THE statement has often been made that steel works power equipment is slipshod and behind the times; that the only reason such methods exist is that the power is only a small fraction of the cost of making and rolling steel. The purpose of part of this paper is to show that such is not the case; that regardless of the relative cost in the finished product the power consumption in the steel works is of such magnitude and the possibilities of saving so great that careful attention to the power and fuel problem is needed and is given. The balance of the paper is to show some of the savings possible, the methods used, and some of the difficulties met with in keeping abreast of the times. The steel works power plant, while usually compared with the central station on account of its magnitude, has more varied problems to meet than almost any other industry. More entirely different kinds of fuel have to be handled and the power equipment is usually more widely scattered and of a more diversified nature than will be found anywhere else.

In some cases the remarks are not limited to actual operating installations, but there is included a description of equipment or methods that are now being contemplated, or are still in the design or experimental stage.

Boilers.

There are many kinds of efficiency obtainable in a boiler house, some of which can be made to go hand in hand, while others are ordinarily opposed to each other. The principal kinds, i. e., those which most interest steel works and power plant managers, are investment efficiency, fuel efficiency, labor efficiency and efficiency of product, which is usually looked upon as quality of product. Most of the new plants show to some extent investment efficiency, that is, greater capacity is being obtained from a given amount of equipment; practically all show labor efficiency in that each new plant built produces more boiler hp or more kw hours per man than older plants. It is now realized that the greatest fuel saving with present equipment can be obtained in the boiler room and that more care is needed to maintain that efficiency than anywhere else in the power plant. Efficiency of product is obtained in various ways, one of which is superheating the steam, thus rendering a given amount of heat able to produce more work. Unfortunately there are two kinds of superheated steam, pure or clean steam and dirty steam. Whether the steam is clean or dirty depends, not upon the superheater, but upon the boiler.

Clean feed water is obtainable only in a central station where condensate from surface condensers and evaporated make-up water are used for boiler feed. In a steel works or power plant where a large percentage of the steam has to be condensed in jet condensers or scattered around a large plant, water with more or less dissolved salts and organic matter has to be used for boiler feed. While most of the scale-forming and the suspended and organic matter can be removed in a water-softening plant, considerable quantities of dissolved salts remain and unless the boilers are designed to produce and deliver dry steam to the superheaters, this moisture is evaporated and the dissolved salts carried into the lines as a powder to cause leaky valves, scored engine cylinders and rods, and reduced turbine efficiency by wearing or depositing upon the blades.

Since most of the boilers today are merely developments of the boilers built when 100 per cent rating was the maximum ever demanded and before the days of superheat, absolutely dry steam cannot be expected with dirty feed water and ratings of 200 per cent or more, unless special provisions are made for extracting moisture. Formerly, while dry steam was desired, it was not essential and comparatively little was done to produce a boiler which could deliver dry steam from dirty feed water. Recently, however, the increasing use of superheat has caused the advent of separating dry pipes, which are something more than mere steam collectors, and to the attempts on the part of some boiler manufacturers to design a boiler which will produce dry steam at high ratings. These attempts consist mainly of unrestricted water flow, large liberating surface, large water surface, large and high steam space, avoiding the removal of steam directly above the water liberating surface, and by separator drums. Drying tubes or heated steam circulating tubes, while producing dry steam, do not remove the dirt from it, and consequently cannot produce clean steam unless all of the dirt and salt freed from the evaporated moisture is deposited in the tubes and adheres to them. Even if this were possible it would mean rapid stoppage of the tubes until the drying effect would be lost due to the deposit.

Investment, fuel and labor efficiency are all increased by the use of large boiler units as less space is required for a given capacity, the radiation loss is lower since the wall surface is less per boiler hp; with modern stokers or other fuel burners one man can handle one or more large units with almost the same facility as the same number of smaller units; and control apparatus, instruments, and attention can be applied to a large boiler at a much lower cost per Bhp. than to a small one, and, as will be shown later, these pay big dividends on a small investment.

Investment efficiency has been increased by running boilers at high ratings, 200 to 250 per cent now being common practice, with some plants being designed for 400 per cent or more. With stoker firing it is still a question whether or not 400 per cent is the limit, as operating troubles increase due to a deposit of sticky ash on the tubes, burning of tubes, priming, and melted, buckled or slagged brickwork. Most of the present types of boilers are unsuited, but except for the slagging of the tubes it is possible that certain boilers or improved designs can be run economically at ratings considerably higher than 400 per cent provided they are equipped with economizers. Slagging of the tubes could be avoided by properly burning pulverized coal. At very high ratings, even with ordinary boilers, induced draft fans have to be used, as stacks for natural draft would be abnormally large and expensive.

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An attempt to secure high boiler efficiency by long and tortuous gas passages has been made in several instances, induced draft fans being installed to supply the necessary draft. However, since the fans, even with electric drive may consume as much as 5 per cent of the boiler output or in other words decrease the net efficiency by 5 per cent, and since, for an equal capacity and fan loss, economizer surface could be installed which would give a higher efficiency, this does not seem to be the final solution to the fuel saving problem.

The question of draft loss through the boiler brings to mind the question "Which type of boiler is best and most efficient?" This opens the way for quite a few arguments and many qualifying conditions, but it seems to be true that for a given heating surface, provided the water circulation is good so as to rapidly remove steam from the tube surface and prevent it from becoming steam bound, the efficiency is a function of the draft loss, and will be practically the same in any boiler for a given draft loss if the tubes are so arranged that the gases are brought into fairly intimate contact with them. This limits the selection of a modern boiler to the one that will generate the dryest steam, which is most easily cleaned and repaired, and which requires the least repairs. Many boilers have been built in Europe which give good fuel economy at ordinary ratings, but which are quite complicated and difficult to clean or repair and which could scarcely be run at ratings demanded in this country.

With very clean water, ease of cleaning is not so essential, but with the feed water usually obtainable around steel works it is a big factor in the selection of a boiler and is very seriously considered.

Since a modern boiler plant has so many advantages over some of the older ones, not only in fuel economy, but in saving of labor, many of the older boiler plants are being, or are to be replaced. There is quite a saving to be made in most cases, even though the old boilers still have a life of from five to ten years.

Boiler Settings.

The design of the boiler settings has become the subject of as much study as the open-hearth furnace. This is due to the number of factors which must be taken care of in the case of a large boiler to be operated at high ratings. The setting of the boiler can limit its capacity and economy by limiting the flame temperature that can be maintained in the combustion chamber. This means that excess air is used merely to keep the brickwork cool; for the same reason the total heat that can be generated in the combustion chamber is limited and therefore the capacity of the boiler. Unless expansion and contraction are cared for, large cracks open up every time the boiler is cooled off, and even during operation, on account of the great difference in temperature between the inside and outside wall surface. The walls bulge inwardly and eventually fall in. With forced draft stokers, the jet action of the flame cuts grooves or niches in the walls and the spouting or piled-up ash adheres to the side walls until it interferes with the movement or distribution of the fuel bed, causing excess air and unburned fuel loss.

Expansion strains and the bulging of the walls have been partially taken care of by making the inside of the walls the concave side of an arch running either up and down or across the boiler and by using an occasional row of tile which extends through the entire thickness of the wall. These tiles tend to tie the inner and outer portions of the wall together. The use of common or face brick in settings for large boilers has been practically eliminated, due to differences in expansion and to differences in size which usually mean thick joints in one kind of brick or the other, a factor which greatly tends toward distintegration and air leakage.

Walls have been built completely of tile of sufficient length that only one row is required for the thickness of the wall, and with fair success. In at least one plant the entire side walls consist of tile, each of which is fastened to supporting steelwork. This scheme not only prevents the wall from bulging and falling in, but also enables any small portion that should become burned or prove defective to be readily replaced.

Steel jackets or casings for boilers save their cost over ordinary practice in less than a year by helping to keep the brickwork in shape and eliminating air infiltration. However, in order to do so they must be made rugged and tight. Several casings have been installed which had so many packed joints that the labor required was almost as much as to keep an unjacketed setting tight. Steel casings for boilers to be fired with coal and operated at high ratings should be given careful consideration, as a small amount of air leakage through the brickwork is almost essential in order to keep from burning it. The steel casing enables the air infiltration to be controlled and kept at a minimum. Plastic coatings may be had for boiler settings, which as long as they are kept in condition prevent excessive air infiltration and are well worth while; but they do not have the advantage of holding the brickwork in shape and it is hard to permanently close up large cracks with cement and plastics.

The brickwork in blast furnace gas fired boilers does not have to withstand the temperatures that are encountered in coal fired boilers, but air leakage has just as serious results upon efficiency so that steel casings are undoubtedly one of the best paying appliances that can be installed in a gas fired boiler plant.

The following table shows the results of air leakage:

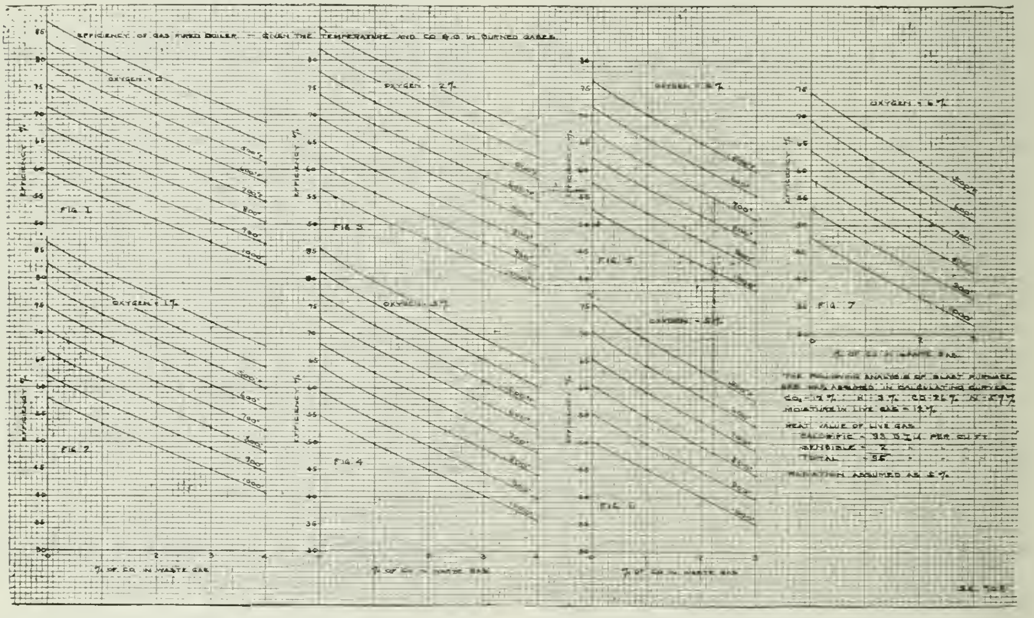
Effect of Excess Air in Blast Furnace Gas Fired Boilers, Showing Percentage Loss in Boiler Efficiency for Various Percentages of Excess Air.

Stack Temperatures	Excess Air						
	25%	50%	75%	100%	125%	150%	175%
500° F.	1.50	3.00	4.52	6.03	7.53	9.04	10.50
550° F.	1.69	3.39	5.08	6.78	8.47	10.14	11.84
600° F.	1.88	3.77	5.65	7.53	9.40	11.30	13.18
650° F.	2.03	4.07	6.10	8.13	10.20	12.20	14.25
700° F.	2.24	4.48	6.72	8.98	11.20	13.45	15.70
750° F.	2.41	4.82	7.22	9.65	12.05	14.50	16.86

Losses presented in the center of above table show actual operation in one modern gas fired boiler plant under test conditions, most of the excess air being due to infiltration.

Ten per cent difference in efficiency in a 1,300 hp boiler amounts to $15,000 or more difference in fuel cost per year, while a complete steel casing could be installed for about $5,400. The latter figures are based upon ¼-inch plate, riveted and caulked, and covering not only the four sides but also the top of the boiler. This would last as long as the boiler and require practically no repairs. A cheaper casing, which would save the above losses, could be installed for half that amount, but it would need considerably more attention. Steel casings are installed in a large number of new plants and the only arguments heard against them are from those who have had experience with poorly designed or poorly constructed casings.

Another feature which is very applicable to blast furnace gas fired boilers is the use of a layer of high-insulating material in the setting walls. On account of the comparatively low temperatures encountered no cooling of the walls is required and, therefore, as much insulation as practicable may be applied, resulting in an increase of two or more per cent in boiler efficiency and paying large dividends on the additional investment. This investment is not large as the insulating brick usually replace an equal amount of firebrick. For coal fired boilers, on account of the high temperatures, the necessity for cooling the brickwork and the desirability of having the walls as homogeneous as possible in order to take care of expansion strains, the additional insulation is not nearly so applicable, although installed in many plants.



It is becoming more and more realized that supporting steelwork has no place in the brickwork of the setting, as the brick and steel expand differently and drumheads, projecting through the setting, shift. Thus large cracks open up between the steel or drums and the brick. These cracks are next to impossible to keep tight unless inspected daily. The boiler of the future will have all drumheads inside the setting and all steelwork outside, thus avoiding these sources of excess air loss. The advantages are well known, the principal thing preventing their instant adoption being the difficulties that arise in changing a comparatively standard design, and a slightly more expensive boiler. The extra expense, however, is known to be more than cared for by operating savings.

Only the best grade of firebrick obtainable should be used for the combustion chamber walls in a coal fired boiler as the slight difference in cost will be saved several times by freedom from repairs and operating trouble. Many of the large power plants have devoted quite a lot of time and money to obtain better refractory materials for their boiler settings. This experience and that obtained in the steel plants on furnaces should not be overlooked in obtaining brick for coal fired boiler settings, where temperatures often exceeding the fusing point of ordinary firebrick are encountered.

Waste Heat Boilers.

The fact that enormous quantities of heat are thrown away in steel works is clearly recognized by everyone connected with them. The only question is, does it pay to install means for saving this heat; does the expense of installation and of the operating costs more than overbalance the saving? The fuel to melt and heat steel has in many cases been better utilized by the installation of waste heat boilers, since that is the most logical method of preventing this waste at the present time.

Waste heat boilers early acquired a bad reputation in many plants, which upon analysis seems due, in addition to improper selection of equipment, to poor installations, i. e., cramped, dark and inaccessible locations, too light or too small fans, air leakage and poor auxiliary equipment.

While in some cases lack of space cannot be helped, yet many installations suggest that the installers thought, since the fuel or source of heat was free, that everything else should either be free or as cheap as possible.

Some of the more modern installations have been very successful on account of the following:

Proper location for room, access and repairs. Preferably grouping to insure attendance.

Proper selection of boiler and setting with a view to obtaining an air-tight setting.

Use of steel jackets, or the coating of settings with plastic covering. On account of high draft in waste heat boilers, namely, boiler draft loss plus furnace draft, the amount of air leakage is far greater than on separately fired boilers unless settings are tight.

Selection of rugged fans and drives of ample capacity. Fans can now be obtained that will not require inspection or overhauling any oftener than the source of waste heat.

Installation of reliable accessories, such as feed water regulators in duplicate, thus reducing attendance and danger to the minimum.

Attention to and means for cleaning.

Installation of special boilers designed particularly for waste heat service.

In most plants where the waste heat is not utilized, the boiler hp which could be developed thereby has to be developed by burning coal. In the modern coal fired boiler plant the cost of the boilers and the settings amounts to only 20 per cent of the total cost of the plant. Waste heat boilers require no expensive buildings with coal bunkers, no coal and ash handling systems including the requisite space, and do not require wide spaces between boilers or between boilers and walls for operating. They also require no stokers, ash pits, or forced draft fans. Therefore, even if a coal fired plant can be operated at an average rating of 200 or 250 per cent and waste heat boilers can only average 70 per cent rating, it still pays from purely an investment standpoint to install waste heat boilers, on account of the saving in auxiliary equipment and buildings, even though more heating surface has to be installed.

On account of the low ratings, waste heat boilers, if properly installed, should have no tube trouble, except from turbining which should be charged to dirty water and not to the boilers and which will be less than in boilers operating at high ratings on the same water. Slag and soot troubles are no greater than those encountered in coal fired boilers at high ratings. The brickwork is not subjected to the temperature extremes that coal fired boiler settings have to withstand. Therefore, the repair charges on a good installation will be less per boiler hp developed than for coal fired boilers.

If the boilers are grouped or if they can be connected with a continuous floor or walk way for the water tender and are equipped with proper feed water regulators the operating costs will be low.

As it is not otherwise utilized, waste heat is free and since other costs are lower, i. e., installation, repairs and operating, steam can be produced more economically by waste heat than by coal, and if coal is fired continuously in a plant which has open-hearth or non-recuperative heating furnaces, waste heat boilers can certainly be made to pay.

The entire cost of the fan and drive is often found to be paid for by improved operation or greater capacity of the furnace to which the boiler is connected. The movement which is on foot all over the country to obtain increased production and economy from open-hearth furnaces widens the field of the waste heat boiler. More draft or greater capacity for handling waste gases is generally required in these open-hearth improvements, if the furnace capacity is to be greatly increased. The only way to obtain this without abnormally large stacks is by fans, and the waste heat boilers cool off the gases and increase the life of the fans. In fact they are required in order to make induced draft fans possible with open-hearth furnaces.

Special boilers have been designed and built solely for waste heat service and embody many desirable features in addition to being so proportioned in regard to gas travel and velocities that good capacity and good economy are obtained.

Economizers.

In considering the sources of loss in the boiler plant it is found that by use of proper gas burners, stokers, or pulverized coal burners the efficiency of the plant can be brought to a very creditable point, but even with the best of fuel burning equipment and well baffled boilers there is still a theoretical saving of about 15 per cent and an actual saving of from 5 per cent to 10 per cent of the fuel burned which can be obtained by the use of economizers. This saving is readily calculated or measured and is questioned by no one. The only question then is whether this saving can be obtained without too great an investment, or too great operating costs. The higher the steam pressure and the higher the boiler rating, or the poorer the fuel burning equipment, the greater is the saving by economizers. In practically every instance economizer surface costs less to install than boiler heating surface, and due to greater temperature difference transmits more heat per square foot than the last pass of the average boiler. Due to the heat transferred in the economizer, boiler capacity is increased and a smaller number of boilers are required.

Until the last few years economizers were constructed solely of cast iron. The only reason for the use of cast iron economizers is resistance to corrosion, and that is of major importance unless corrosion can be eliminated by other means. The weight and space requirements of the cast iron economizer are so great that the building cost is greatly increased; due to connecting flues and large exposed wall surface, radiation loss is high; scraper maintenance is high; scraper operation takes power (although little more than soot blowers); air leakage is high where scrapers are used; joints and headers are cumbersome and complicated; repairs are difficult and expensive; cracked headers or tubes are quite likely; there is insufficient capacity for precipitation of scale and sludge; cleaning is troublesome due to numerous handhole caps, and in case a hard deposit is encountered it is more risky to use a tube cleaner than with steel tubes; heat transmission is poorer due to a layer of soot always present in spite of scrapers and to the very thick walls necessary to resist pressure in the case of cast iron. On account of rougher surfaces soot accumulates more rapidly on the outside and sludge on the inside of the tubes. Another disadvantage which is becoming increasingly prominent is that cast iron economizers cannot be used for high pressures without becoming very heavy and bulky with great wall thickness.

In spite of all of the above troubles and disadvantages of the cast iron economizer, there is practically not a single plant which at the present price of fuel could not show some net interest on the investment if cast iron economizers were installed. The reason for their omission in many modern power plants is that an equal investment in other equipment pays a higher rate of interest.

Some of the disadvantages have been ameliorated by changes in operating practice, i. e., by raising the temperature of the inlet water above the dew point of the burned gases, which eliminates external corrosion and sticky soot deposits and permits the use of soot blowers instead of scrapers. There has also recently been an improvement made in design, namely, placing the tubes in a horizontal position. This decreases the space requirements and in some cases makes it possible to install the economizer in the same setitng as the boiler.

It has been proposed, in order to use cast iron economizers for very high pressures and still have a light weight construction, that the water be delivered to the economizer at a low pressure and that a booster pump be installed between the economizer and the boiler. While this arrangement is feasible it leaves the other disadvantages, in addition to pump trouble from high temperature water, and the outfit is still fairly cumbersome.

In many plants room has been left for economizers pending the development of a better paying apparatus. Equipment has been designed and conditions overcome which now insure the success of an economizer using rolled steel, or wrought iron tubes. Which of the two materials is better depends upon the same factors that determine which makes the better pipe. A steel tube economizer is cheaper, lighter, occupies less space and has better heat transmission than a cast iron economizer for a given condition. It can be installed integral with the boiler and thus eliminates much of the radiation, air infiltration and draft losses. Soot blowers are readily used and have a long life due to low temperature in the economizer.

Steel tube economizers can be operated safely by heating the feed water in an open heater and then removing the dissolved gases under vacuum in another vessel. If the water does not contain acid, which would cause corrosion in the boiler or even in a cast iron economizer, internal corrosion in the economizer will be eliminated. Apparatus for deaerating the feed water is now on a commercial basis and requires little attention and power for its operation. External corrosion, as well as a sticky clinging soot deposit, will be eliminated by delivering the water to the economizer at a temperature above the dew point of the burned gases, which is not more than 120 degrees to 130 degrees F. in ordinary practice. This is automatically taken care of by the deaerator as the water leaves above that temperature. Some of the saving possible by the economizer is lost by the use of such hot water, but operating difficulties are eliminated and the before mentioned savings are still obtainable. Another factor which would probably pay all of the expenses connected with the deaerating apparatus is the improved vacuum and decreased air pump operation due to the elimination of air in the steam going to condensing engines or turbines.

In one instance the net interest on the investment in a steel tube economizer, after all operating expenses and repairs, and 13 per cent for interest, depreciation, insurance and taxes was deducted, figured as 20 per cent, while the equivalent cast iron economizer installation showed only 5 per cent net interest. In each case the increased building cost, the saving in boiler installation and all allowance for operating costs were taken care of, but no allowance made for the increased heat transmission through the steel tube economizer, the same coefficients being used that have been found to apply to cast iron economizers. The above figures were based upon 250 pounds steam pressure and 180 per cent boiler rating. With higher steam pressures and higher boiler ratings, the saving by the steel tube economizer would have been much greater as its cost increases very little from 250 pounds to 350 pounds.

The fan power for an economizer is not any more than is required for some boilers that have been installed to obtain higher efficiency, since although the draft required may be higher, the gases are colder and the volume to be handled is less.

Steel tube economizers should be attractive to steel works on account of the material used and great development should be made there on account of the facilities for studying the steel and its action, in addition to the fact that it develops another use for steel. Their prominence today is due to a large extent to steel works engineers, even though, as yet, no large installations have been made by them.

Air Heaters.

The use of preheated air is not new, neither is the idea of its use in connection with boilers, but until recently it was very little considered, probably on account of the low price of coal. The air heater for a boiler must not be confused with the recuperator on a heating furnace, where extremely high temperatures make its life fairly short and require a fairly expensive construction, although even here it pays good dividends if properly taken care of. In connection with boilers the tubes are only required to handle gases at from 500 degrees to 750 degrees F. as against 1300 degrees or more in a heating furnace.

The advantages of the air heater over an economizer are cheaper and lighter construction, no pressure to resist, small building space, freedom from soot or dust, and safety. With fairly clean blast furnace gas no dust adheres to the tubes, if properly designed, i. e., if gas velocities of over 300 feet per minute are used and the tubes are vertical. One air heater has been in operation for two years with no deposit of dust on the tubes.

The value of the air heater with stokers is still doubtful, due to the fact that the air supply is used not only for combustion, but also for cooling the metal parts of the stoker. Also with stokers there is the possibility of coking or caking the coal, fusing the ash, and of brickwork troubles due to high temperatures, which are eliminated with gas or powdered fuel. An air temperature rise of 300 degrees F. is available, but due to the need of cooling the stoker parts, most power plant men hesitate to install air heaters in connection with stokers.

With blast furnace gas and powdered coal, however, full value may be obtained from preheated air with no increase in repair cost other than the upkeep of the air heater. This is very small due to the comparatively low temperatures, that is, no higher temperatures than steel is called upon to withstand in superheated steam piping. As with economizers the higher the boiler rating and the higher the steam pressure, the greater is the saving by the air heater.

More has been done in steel works than anywhere else toward the use of air heaters and this holds good in boiler practice, as there are now one operating and several contemplated installations.

Gas Burners.

Increasing attention is being paid to burners. The ordinary burner found in many plants requires constant adjusting to proportion the air supply to the varying gas pressures. Even if this is watched closely, such burners do not attain thorough enough mixing to insure combustion before the gases strike the tubes, unless the combustion chamber is abnormally large, with consequent radiation loss. The unburned gases are chilled, thus either burning in the last pass, causing high stack temperature, or causing high CO in the stack gases, with acompanying loss, or both. Recent burner development is along either of two lines: first, with an aspirating type of burner which uses the gas velocity to draw in the correct amount of air for combustion at all ratings; or secondly, an air fan combined with a regulator to automatically supply air to the burner independently of draft and in correct proportion to the gas flow. In both cases the air and gas ports are subdivided, giving alternate thin layers of air and gas, and attention is given to securing proper gas velocities for thorough mixing. The second type of burner is fairly complicated and expensive where there are numerous small boilers, but is well worth the expense for large units. The aspirating burner is well adapted to small units, as it can be installed for very little more than a common "gas feeder," requires no expert attention, and has no maintenance. For example, a 300-hp boiler at about 120 per cent rating equipped with goose neck burners, while running with 6 per cent oxygen, showed 2 per cent CO in the stack and a stack temperature of over 800 degrees F., or a boiler efficiency of approximatly 46 per cent. Equipped with aspirating burners the same boiler averaged day after day 23 per cent CO_2, no CO and 600 degrees F. stack temperature, giving a boiler efficiency of 73 per cent.

The curves in Figs. 1 to 7 show boiler efficiencies when burning blast furnace gas with various flue gas analyses and stack temperatures. They also show the efficiencies possible with good burners, proper baffling of boilers, and by economizers or air heaters. Seventy per cent efficiency is being obtained by modern burners under ordinary installations of small boilers, while higher efficiencies are obtained with larger units and boilers with longer gas travel.

The following shows how well it pays to install efficient burners even in an old installation with only a few years more life. A 400-hp boiler at 125 per cent average rating equals 500 Bhp. If the boiler efficiency is increased only 10 per cent, say from 60 to 70 per cent efficiency, which is quite possible as seen from the curves, saving per hour is:

(tons of coal per hour at 60 per cent)—(tons of coal per hour at 70 per cent.) × (price of coal) = (saving)

$$\text{or}\left(\frac{500 \times 33479}{.60 \times 13{,}500 \times 2240} - \frac{500 \times 33479}{.70 \times 13{,}500 \times 2240}\right) \times \$5.00 = \$\,.66$$

At 300 days of operation the saving per year is 300 × 24 × $.66 = $4,752.

Aspirating burners for a 400-hp power boiler can be installed complete at present prices for $800. Thus there is a yearly saving of about 600 per cent on the investment, and no repairs to be ever charged against the installation. In addition there is a saving in labor since hand regulation is practically eliminated. The 10 per cent saving is very conservative as the difference between ordinary and good burners is usually higher, due not only to better combustion, but also to lower stack temperature on account of quick combustion. On account of rapid combustion and with dry cleaned gas, higher capacities are obtainable from the same setting and troublesome boilers can often be eliminated by the installation of modern burners under the other boilers.

The efficiencies shown at the upper left-hand corners of Figs. 1 to 4 are readily possible with good burners and preheated air, the waste gases being used to heat the air for combustion.

Gas Cleaners.

While not part of the power plant, gas cleaners have such a close bearing upon its economy and are so closely allied to the furnace and steelworks power that some mention should be made of them.

In blast furnace and steel plants increasing attention is being paid to the utilization of gas, since, even on the same fuel cost basis, a boiler horsepower can be produced more cheaply with gas than with coal. This is due to the elimination of coal and ash handling machinery and stokers, cheaper buildings and less operating labor. Therefore, anything that increases the output from gas and eliminates coal firing is worthy of attention. Considerable interest is being shown in gas cleaning methods particularly those in which the temperature of the gas is not lowered by the process.

Dry cleaners, electrical methods of precipitation and new designs of whirlers are being installed, and are the subject of considerable experimentation. The reason for this is that 6 to 14 per cent of the total heat of the gas is sensible heat and can be saved by a good dry cleaner. This means an average fuel saving of $20,000 or more per year per furnace.

In order to have the sensible heat of the gas many plants equipped only with inefficient wet cleaners, which reduce the temperature without a commensurate cleaning, are burning raw gas under boilers and find a considerable saving in spite of more labor in cleaning settings and blowing tubes.

Stokers.

Even with the best boiler to be had or the best boiler possible to produce, good efficiency, free from excessive operating troubles, will not be obtained unless careful attention is paid to the fuel burning equipment. As previously stated this is more of a problem in a steel works than in a central station on account of the diversity of the fuels used.

The general tendency is to burn only one type of fuel under a given boiler; either gas, coal or coke breeze. However, installations are contemplated with both stokers and blast furnace gas under the same boilers, the stokers to operate when the gas supply is deficient; and in many cases coke-oven gas is burned in connection with coke breeze. However, the gas is used mainly to help ignition and when in surplus.

Several new makes of stokers have appeared on the market recently and at least three of these have been selected for steel works installations. For burning coal, underfeed stokers have been installed in most coses with a marked tendency to the extra long type. One of the most noticeable features is the use of air-cooled dead plates, wind boxes or side tuyeres, and of special brick with holes for air admission along the side walls, all of which are designed to protect the walls and avoid the use of steam jets.

For burning coke breeze, the accepted stoker seems to be the forced draft traveling-grate type. The mechanical difficulties of this type of stoker appear to have been solved, the greatest source of trouble being arches, other brickwork and ignition. Considerable experimentation has been done in plants equipped with traveling-grate stokers on arches when burning coke breeze. Various types of flat and sprung arches at various heights and angles have been tried and ignition problems solved by the proper arrangement of the arch so that the radiant heat from the fuel bed is absorbed by the arch and radiated or reflected to the green fuel. Ignition is assisted considerably by proper application of the forced draft under the front of the stoker so as not to pass too much cold air through the fuel before it is properly ignited. One make of stoker has means provided to obtain a suction under this front section and draw hot gases down through the green fuel. This is similar in effect to the practice of carrying a pressure in the combustion chamber on coke breeze stokers, which practice, however, is very detrimental to the brickwork. Many boilers are equipped with burners for coke oven gas so located as to produce a flame under the ignition arch. These are used to help ignition of very poor or wet coke breeze.

In plants which have no coke ovens there is coke breeze, screened out at the blast furnaces, from which 200 to 300 Bhp. per furnace is obtaniable. Many plants rather than install separate stokers are burning coke breeze on underfed stokers or on hand-fired grates with forced draft. It has been burned successfully on underfeed stokers either straight or mixed with coal. When burned without coal, coke breeze requires about three times the labor necessary for straight coal. However, mixtures of 25 per cent coke and 75 per cent coal are being burned with practically no additional effort.

During the past year many plants have not only consumed successfully all the coke breeze obtained from their furnaces, but have considerably reduced stock piles of breeze accumulated while coal was plentiful.

While much credit for stoker development is due central station engineers, most of the low-grade fuel development has been accomplished in the steel works.

(To be continued)

Molybdenum and Molybdenum Steels

Occurrences of Molybdenum — Manufacture — Properties and Uses—Molybdenum In Steel, Over One Per Cent, Less Than One Per Cent—The Manufacture of the Steel Itself.

By ARTHUR H. HUNTER,*
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THE root from which the word molybdenum was derived was molybdos, the Greek word for lead, and in the work of Pliny, molybdaena was a designation applied to various substances containing lead. In the eighteenth century, the usage of the word molybdaena was contracted to embrace the minerals graphite and molybdenite only, which resemble each other in color, luster and hardness and were then thought to be the same. In 1778 Scheele proved that molybdenite (MoS_2) was not graphite and the element molybdenum was isolated therefrom by Hjelm in 1790. Mendeleeff classified the element in group six of the periodic table between chromium and tungsten.

Occurrences of Molybdenum.

The deposition of molybdenum in the crust of the earth is always in the combined state with oxygen or as the compound of sulphur (MoS_2).

Molybdenite contains 59.95 per cent of molybdenum and accounts for more than 90 per cent. of this mineral resource. Specimens of this mineral are reported throughout the world in rocks of igneous, metamorphic and sedimentary origin in numerous geological occurrences and distributions.

The deposits of major commercial importance so far developed are situated in one or two districts in the respective countries of Canada, Norway and Australia and within a few States of the United States. With the exception of the State of Colorado, an examination of the available data on all other properties shows lodes of ore of limited width and restricted continuity, the metal being prevalent in large flakes, exhibiting in places a run of mine content of 5 per cent or more molybdenite. The formation in Summit and Lake counties, Colorado, is a massive low grade deposit uniformly distributed through an altered granite, according to the U. S. Geological Survey. In dimensions and tonnage this is comparable to the well-known porphyry copper deposits of the United States. The molybdenite occurs in flakes that are almost microscopic in size disseminated through the rock. The ore mined averages a uniform content of .8 per cent molybdenite with a variation that rarely exceeds .1 per cent.

The oxygen compounds of molybdenum in nature definitely established are listed as eight in number with a varying content of from 3.4 to 68.18 per cent molybdenum of which six may be classed as of mineralogical interest only. Of the remainder, molybdite is an alteration product of molybdenite; and wulfenite ($PbMoO_4$) containing 26.16 per cent molybdenum in deposits capable of yielding tonnage is confined to the State of Arizona, according to present statistics, with indications that the available resources of this mineral are limited.

The elements, phosphorus, copper, arsenic, antimony and bismuth, when in association with molybdenum are often detrimental to the finished product and cannot be appreciably eliminated by reason of the limitations of the metallurgical processes for the economical conversion of the raw material. Thus, a good portion of the molybdenite known throughout the world will not be available for commercial use unless processes are devised to overcome this objection.

Manufacture of Molybdenum.

The primitive method of mining molybdenum ores was to break the rock by hand and sort out a high-grade product. This is wholly unsuited to present day requirements. Mining operations on a commercial scale involve installations that mechanically function to pulverize the ore and physically separate the metallic constituent by means of oil flotation into a concentrate that analyzes from 50 to 90 per cent molybdenite. These concentrates are converted into ferro-molybdenum, salts of molybdenum and metallic molybdenum, having a relative consumption in the order mentioned, estimating ferro-molybdenum as 95 per cent or more of the present total.

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* Paper presented at the American Iron and Steel Institute, May 27, 1921.

The conversion of molybdenite is effected by electrothermic processes directly from the sulphide by an admixture of lime and carbon or other reduction methods. In the indirect process the molybdenite is converted to oxides or halides which are reduced to metallic molybdenum by reaction with carbon, hydrogen or other reducing agents. With this is also included the aluminothermic processes. Alloying iron with molybdenum forms ferro-molybdenum.

Properties and Uses.

Metallic molybdenum is a white metal resembling platinum. It has an atomic weight of 96, is ductile and soft, and has a melting point around 4500 degrees F.

Metallic molybdenum of requisite purity to fulfill the manufacturing operations is worked into wire and sheets for use alone or alloyed with tungsten as an electric resistor in heating and lighting apparatus. Precautions are taken to provide a surrounding substance so the metal will not oxidize. When alloyed with tungsten it is said to be a partial substitute for platinum.

Molybdenum forms many compounds with oxygen and likewise sulphur of which the prevailing sulphide is MoS_2 and the oxide MoO_3. The sulphides, as such, have no commercial applications and the oxide MoO_3 has a very limited use. With the halogens and cyanogen a large number of salts have been prepared, some of which are quite complex. Molybdenum will also combine with nitrogen, phosphorus, boron and silicon.

Molybdic oxide is the basis for the manufacture of a number of commercial salts of which certain ones are used for the manufacture of molybdenum steel and in the chemical laboratory for the analytical determination of phosphorus. Some of these salts are used as a pigment in pottery, rubber, textiles and leather; to purify and recover alkaloids and for blue print paper.

Ferro-molybdenum as employed in the manufacture of molybdenum steel is supplied in analyses that range from 50 to 90 per cent. molybdenum, preferably from 50 to 60 per cent, which alloy has the lowest melting point at about 2600 degrees F. and will therefore diffuse more rapidly and uniformly through the steel bath. The relative amounts of the copper and phosphorus in ferro-molybdenum should not exceed 1½ times the content in the concentrates when the conversion is properly conducted.

Molybdenum alloyed with the higher percentages of chrome forms an acid resisting alloy and indications are that it produces beneficial properties when alloyed with bronze and brasses.

Molybdenum in Steel—Over One Per Cent.

The principal use of molybdenum, however, is—of course—in the manufacture of steel. The earliest experiments, dating back more than twenty-five years, were confined almost exclusively to the effect of relatively large percentages of the element in high speed tool and magnet steels.

Molybdenum in High Speed Steel.

From the earliest advent of high speed steels, it has been sought to replace tungsten as the principal alloying element in such steels with molybdenum. This has seemed feasible because in a general way its hardening effect upon steel is similar to that of tungsten, but to date efforts along these lines have not met with much success. Arnold and Ibbotson* have placed the ratio of the hardening power of molybdenum to that of tungsten at 2.3 to 1, meaning that 2.3 times as much tungsten as molybdenum must be used to produce the same effect.

Molybdenum high speed steels have generally contained from 5 to 8 per cent of this metal, but investigators invariably report that in these percentages molybdenum acts erratically and that while occasionally excellent results are obtained, it is difficult to duplicate them and further that the molybdenum has a tendency to volatilize out of the surface of the steel when it is heated for forging, rolling or treatment. This makes the steel unfit for use except in tools which permit of considerable grinding in order to remove the skin of material which has been rendered useless. Because of these characteristics, investigations have followed the line of endeavoring to discover some element or elements which in combination with molybdenum would act as a stabilizer for the latter.

In 1919, Arnold and Ibbotson† reported on an extensive research embracing several types of high speed steel, the chromium content being kept constant and the content of tungsten, molybdenum and vanadium being the variables. The steels were rated in the following order according to their cutting efficiencies:

1. Molybdenum-Vanadium
2. Tungsten-Vanadium
3. Tungsten-Molybdenum-Vanadium.
4. Tungsten-Molybdenum
5. Tungsten
6. Molybdenum.

The authors also state that with about 1¼ per cent vanadium present, the ratio of hardening power becomes 2.7 to 1. From these tests it is to be inferred that the presence of the vanadium had overcome the tendency of molybdenum to show erratic results. However, there is nothing in the report to indicate that surface volatilization had been eliminated by this means. The lathe tools used had considerable metal removed from the cutting edge by grinding before being tested. It has recently been reported from abroad that cobalt, together with vanadium, has produced the much sought after stability of the molybdenum alloy in high speed steels. Dr. Mathews,‡ however, asserts that these elements, both alone and separately, were thoroughly investigated in this country in pre-war years without success and that a recent test by the Halcomb Steel Company had verified the fact that molybdenum was not to be stabilized in this way.

It can be confidently stated, therefore, that while there are many eminent metallurgists who believe that there is promise that this problem will be solved and a method will be evolved permitting the efficient employment of molybdenum in steel in percentages greater than 1 per cent and as a substitute for tungsten in high speed steels, the commercially successful molybdenum high speed steel has not yet been produced.

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*Proceedings (British) Institution of Mechanical Engineers (Nov., 1915).

†Journal (British) Iron & Steel Institute (1919, Vol. XCIX, No. 1).

Molybdenum in Magnet Steels.

Dr. Mathews[°] points out that magnet steels having a molybdenum content of from 2 to 4 per cent were investigated by Madame Curie[§] in 1898, and by himself and Dr. E. L. French in 1902, and that while permanence values were good the steels were lacking in residual density. Since these tests were made there has been no effort, to the writer's knowledge, to promulgate a molybdenum magnet steel. This problem has probably an intimate connection with the above mentioned difficulties when molybdenum is present in the higher percentages and until a way has been found to bring the effect of this element on steel, in quantities greater than 1 per cent, under proper control, there is small likelihood that molybdenum will play an important part in permanent magnet steels.

Molybdenum in Steel—Less Than One Per Cent.

It has long been recognized that molybdenum when present in steel in quantities up to 1 per cent was subject to none of the drawbacks mentioned above. Dr. Sargent[*] has called attention to the fact that Leon Guillet in the Revue de Metallurgie, 1904, showed its favorable effects on the strength and ductility of mild steel when added in fractional percentages and that Thomas Swinden[†] in 1911 indicated that from a commercial standpoint mild chrome-molybdenum steel might well replace the high-grade nickel-chromium steels then on the market.

It is in this field of mild steels for structural parts of machines requiring high elastic properties that the present development in connection with molybdenum occurs and this development came about during the war and was almost exclusively confined to this country. True, there was a large demand for molybdenum from Europe in the course of the war, but this demand was chiefly from England where the shortage of tungsten was acute and molybdenum offered the best substitute in the manufacture of tool steels. There were rumors that the Germans were using a molybdenum bearing steel in cannon and the French added this metal to the high-grade nickel-chrome steels employed in heavy breech blocks, but it was American munition makers who made the widest use of molybdenum steels in light armor plate and the vital parts of aeroplane motors, automotive vehicles, etc.

There is no doubt that the development on a commercial scale of structural steels containing less than 1 per cent molybdenum was greatly retarded by the supposed rarity of the metal and the difficulty of obtaining it in sufficiently pure form to guarantee the production of sound steel in tonnage quantities. Early investigators were certainly discouraged because of the low-grade material with which they had to work. The war demand, however, stimulated research and led to the discovery and development of large and remarkably pure ore bodies in this country and to great improvements in methods of refining, until at present there is an established molybdenum industry assuring the production of this metal in forms which offer no difficulties in the manufacture of steels of the highest type.

The use of fractional percentages of molybdenum for the manufacture of commercial structural steels is due in large measure to the work of Mr. C. Harold Wills of Marysville, Michigan. Mr. Wills, with the assistance of Mr. H. T. Chandler, metallurgist for C. H. Wills & Company, after convincing himself of the abundant ore supply in this country, conducted extensive experiments with molybdenum and practically all other possible steel alloying elements in various combinations.

Molybdenum, always in these small percentages, has been found to have a beneficial effect on the physical properties of mild structural steels when added alone to a straight carbon steel, when added in combination with another element such as chromium or nickel to form a ternary steel, or when added to a ternary steel to form a quaternary steel such as chrome-nickel-molybdenum steel or chrome-vanadium-molybdenum steel and this strengthening and toughening effect has been found to be progressive as the content of molybdenum is raised from a small fraction of 1 per cent up to 1 per cent. For the more general structural purposes, where extreme properties are not required, the combination of chromium and molybdenum has been found most efficient when commercial factors are taken into consideration. Where more exacting duties are imposed, one of the more complex quaternary steels mentioned above should meet the requirements. In cases where the steel must pass through difficult cold forming and pressing operations, it has been found advisable to employ a simple low carbon steel with the addition of molybdenum alone.

Molybdenum added to carbon steels, especially those of extremely low carbon content is largely in solid solution in the ferrite to which it adds both strength and ductility. Where chromium is present, however, together with sufficient carbon, it seems probable that the molybdenum acts in two ways, the greater part combining with the chromium and carbon to form complex carbides and the balance being diffused in the ferrite.

A great deal has been published recently on the action of molybdenum in steel considered primarily from a technical standpoint. A summary of the purely practical and commercial features of this alloy might be of greater interest at present than a more technical résumé and with this in mind the following is presented.

From the strictly practical viewpoint, there are, broadly speaking, four prime factors to be considered in connection with any steel:

I. The manufacture of the steel itself.
II. The physical properties of the finished steel.
III. The adaptability of the steel to fabrication.
IV. The total cost of the fabrciated articles.

(To be continued)

[‡] Molybdenum Steels, Transactions American Institute of Mining and Metallurgical Engineers (Feb., 1921).

[°] Trans. Amer. Inst. Min. & Meta. Engrs. (Feb., 1921).

[§] Bul. Soc. d'encouragement de l'Ind. (Jan., 1898).

[*] Molybdenum as an Alloying Element in Structural Steels. Trans. A. S. T. M. (June, 1920).

[†] Journal, Iron & Steel Inst. 1911, Carnegie Scholarship Memoirs, Vol. V.

Solid Solution of Oxygen in Iron

Evidence Is Accumulating Which Shows That Many Solid Solutions of Iron and Every Other Element Are Electro-positive to Pure Iron.

By Dr. J. E. STEAD, F.R.S.*

WITH the advent and use of the cupric reagent of Rosenhain and Haughton, Stead, Whiteley, Humphrey, Le Chatelier, Dupuy, and others, the micro and macro study of the structures of iron and steel have passed into a new phase, and evidence is accumulating that many solid solutions of iron and every other element are electro-positive to pure iron.

Phosphorus, nickel, copper, cobalt, tin, antimony, silicon, chromium, carbon, etc., when in solid solution in iron, are of that character, and when placed in juxtaposition with pure iron remain white on being feebly attacked by a cupric reagent.

The most recent and important discovery following the use of reagents of this type is that made by Le Chatelier and Bogitch. It appears to prove (what had long been disputed), that iron could and did alloy with oxide of iron to form solid solution; that such alloys relatively to pure iron resisted the attack of alcoholic cupric solutions, copper being deposited on the latter more readily than on the former.

Although not disputing the findings of these investigators, the author had repeatedly failed to reproduce their results by burning pure electro-iron on a magnesia-lined base in oxygen in such a way that buttons of fused iron were obtained covered by thick layers of cinder. That the buttons were highly charged with free oxide was evident when examined under the microscope, for it appeared in the form of minute black globules.

On polishing and staining with all available cupric reagents the copper always deposited evenly over the surface, and on dovetailing into the specimens strips of the original electro-iron and polishing and copper staining the two surfaces again the copper deposited equally on each. It is evident, therefore, that oxide may, and may not, under very slightly varying unknown conditions, remain in solid solution in iron. The following data afford what appears to be evidence of conditions favorable to the retention of oxide in solid solution.

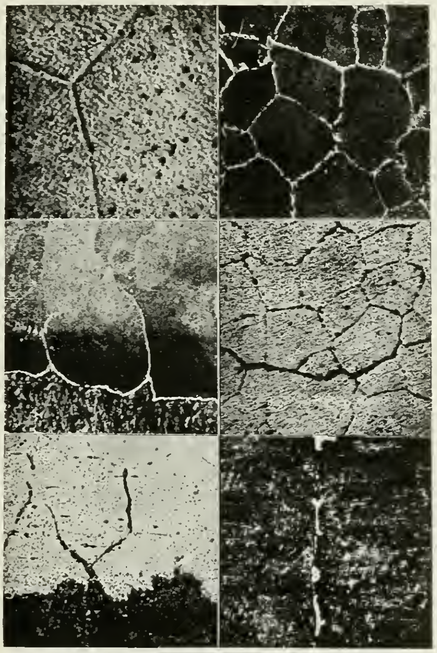

Fig. 1—Junction at a weld in soft steel. Etched by a cupric reagent. × 50.

Fig. 2—Oxidized steel plate showing scale at top, steel below, with intergranular oxides and globular inclusions. Etched by dilute acid. Vertical section. × 50.

Fig. 3—Same as Fig. 2—Horizontal section. The continuous black line is a fracture showing intergranular brittleness. × 50.

Fig. 4—Another section of Fig. 2, etched by a cupric reagent showing white resist lines between the crystals. × 50.

Fig. 5—Horizontal section of Fig. 4, just below scale, cupric etched, showing white resist lines round the crystals. × 50.

Fig. 6—Part of Fig. 5 after long etching and repolishing, showing junctions of crystals in slight relief. × 350.

The author long ago noticed that strips of electro-iron, after heating to 1000 degrees C. in air and removing the scale, were sheathed with a film of finely crystalline iron covering an interior mass consisting of large crystals. On grinding off the fine grained film so as to expose the coarser grained material below and using this as an element of a voltaic cell, the second element being another piece of the strip from which the film had not been removed, and dilute HCl being the electrolyte, the needle of a galvanometer was strongly deflected in the direction which proved that the outer film was electro-positive to the metal below—in other words, that the film was the less readily attacked by the reagent. On applying a cupric reagent to the surface of a similar strip partly denuded of the film, copper was deposited less rapidly on the film than on the portion freed from the external skin.

These observations naturally led to the hypothesis that when iron is oxidized in air so as to produce an oxide scale, a minute quantity of oxygen passed coincidentally into the iron, forming a solid solution.

The experiments were repeated on several specimens of commercial soft steel, and in all cases an external film of metal resistant to cupric reagent attack was formed.

Previously the author had found that gases, etc., passed with greater facility into iron along the intercrystalline junctions of the crystals. For instance, from polished speciments which had been heated in air so as to form an adherent scale, on removing the scale when cold the junctions of the crystals were found to be channelled, showing that oxygen had been the more active at the boundaries of the crystals.

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*From a paper delivered by the author at the annual meeting of the British Iron and Steel Institute, May 5 and 6, 1921.

Bearing on this distinctive property of the intercrystalline junctions, when phosphide of iron diffuses into iron it travels for the greater distance along the junctions, as illustrated by the photomicrograph No. 31 in the author's paper published in the Journal of the Iron and Steel Institute, 1915, No. I.

A most sensitive reagent of the many now in use is that of Le Chatelier and Dupuy. This consists of:

Alcohol (95 per cent.)	100 cm
Water	10 cm
Cupric chloride	1 gramme
Picric acid	0·5 gramme
Hydrolchloric acid	1 to 3 cm

Mr. W. H. Cathcart first drew attention to the fact that on applying a cupric reagent to a cross-section through a weld of soft steel, a white resist line appeared at the junction of the two surfaces—an observation frequently confirmed. This Mr. Cathcart attributed to segregation of some of the phosphides when at welding temperature, but it may be due to more than one cause (Fig. 1).

An example of extreme brittleness in a steel, due to many years' heating in an oxidizing atmosphere, has recently been supplied to the author by Mr. J. H. Harrison. It was taken from the lower portion of the steel casing of a heating stove at the Lackenby Ironworks and was thickly coated on each side with an adherent iron scale. On examination it was found to be brittle, due to feeble coherence between the crystals near the surface. On applying transverse shock, fracture commenced as intercrystalline and continued below the surface through the crystals. On making a section through both scale and steel, the reason for the way in which the fractures started was at once revealed, for veins of oxide of iron completely separated the crystals on the surface layers, as is shown in Fig. 2. For a distance of about one-half millimetre from the surface below the cinder there was a multitude of separate minute globular inclusions varying in diameter.

On sectioning horizontally through this layer and polishing, the oxide could be traced more or less continuously round the crystals (Fig. 3). On bending the section so as to put the polished surface in stress, fracture travelled round and never through the crystals. The dark continuous line in Fig. 3 represents the fracture.

On etching a polished section with a cupric reagent a layer or film of iron just below the cinder resisted the attack, and where there were oxide veins running downwards into the metal the iron adjoining the visible veins of intercrystalline oxide of iron, the junctions remained white, resisting the reagents (Figs. 4 and 5).

Assuming the hypothesis to be correct that previous to the actual formation or separation of free oxide there is formed a solid solution of oxygen in the iron, we are forced to conclude that oxygen has travelled between the grains producing first solid solutions at the junctions, and that in course of time as more oxygen penetrated these became supersaturated and free oxide then precipitated and appeared as detached globules and later as continuous layers. On examining the surfaces of the fractures that passed between the grains many of them were found to be covered by fine dark spots evidently corresponding with the globules of oxide of iron apparent in the polished section.

In order to determine whether the globular inclusions in the body of the crystals were oxide of iron, a polished section was heated in hydrogen gas at 1200 C. The result indicated that although they appeared to have been reduced in size, they still remained.

The free oxide of iron veins were reduced, and there were no longer resisting areas along their borders, suggesting that the original white parts were due to oxygen in solid solution.

The analysis of the sound portion of the steel sheet was as follows:

Carbon	0·025
Manganese	0·539
Silicon	trace
Sulphur	0·040
Phosphorus	0·007

The remarkable feature in this analysis is the very low amount of phosphorus. The question at once presented itself as to whether it was not originally much higher but had diffused to the outside and become oxidized. If that were the case the phosphorus would be concentrated in the scale. This scale was, therefore, very carefully analyzed, but there was no such concentration. The globular inclusions in the body of the crystals were subjected to careful examination. It was noticed on the surface after careful polishing they had the same dove-grey color as larger inclusions of manganese sulphide originally present and were quite different from the iron oxide globules between the grains. Direct sulphur prints obtained by pressing the polished surface upon an acidulated sensitized dry plate or bromide paper indicated that they contained sulphide, but what appeared to be iron oxide also gave sulphur stains. Judging, however, from the color it was concluded that the minute dove-grey globules consisted mainly of manganese sulphide although possibly associated with FeO and MnO. The stains given by the oxide veins and globules led to the determination of sulphur in the thick exterior scale, and 0.8 per cent of sulphur was actually found. It was a surprise to find so much, and it is evident that it must originally have been present in the blast-furnace gas.

How did the sulphur penetrate into the inside of the crystals of iron, and what must have occurred for it eventually to combine and segregate with the manganese? Beyond the facts, at present only conjecture is possible, definite conclusions await further research.

Summary.

Although much more research is necessary before definite conclusions can be formed, the results appear to indicate that:

1. When iron is heated in air or oxidizing gases, apparently the surface layers absorb oxygen which passes into solid solution.
2. When supersaturated the oxide falls out of solution, forming separate globules of free oxide. These globules then become larger and larger as oxidization proceeds, eventually joining together to form continuous layers.

Considerations on the Welding of Steel

Welding Discussed in Relation to the Occurrence of Pipe, Blow-holes, and Segregates in Ingots.

By H. BREARLEY,*

Member of Council (Sheffield).

It is well known that perfectly clean surfaces of malleable metals will stick together under pressure at temperatures much below those commonly used for welding. Platinum is a case in point. As that metal does not readily oxidize, worn vessels can be easily repaired by hammering a piece of hot sheet platinum over the defective part. Hot steel can also be welded together under pressure at low temperatures in an atmosphere of hydrogen or other inert gas. Turnings sometimes stick to the cutting edge of tools which are doing heavy work, and it is on record that a cutting tool has been found welded to a heavy forging which was being machined.

Steel oxidizes at comparatively low temperatures. The temper colors visible on bright steel heated up to 200 degrees C. and beyond are forms of iron oxide which, as the temperature is raised, pass gradually into the more or less adherent oxide of measurable thickness which we call scale. The scale thus formed is a brittle substance whether hot or cold; it is not malleable or plastic, and cannot be welded together. At very high temperatures the scale melts and could be expressed in the fluid condition from between two metallic surfaces, but the temperature at which it remains sufficiently fluid is near the melting point of steel. At such high temperatures the fluid oxide scale reacts with the carbon of the plastic steel, liberating carbon monoxide, or dioxide, which forms blisters. It is, therefore, not practicable to make a respectable weld without using some means of lowering the melting temperature of the scale, and also modifying its oxidizing effect on the hot steel.

Fig. 1—Section of roll-welded plane iron.

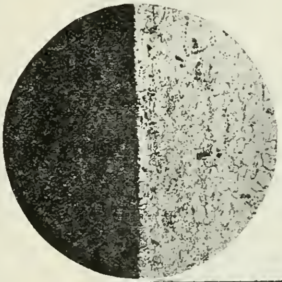
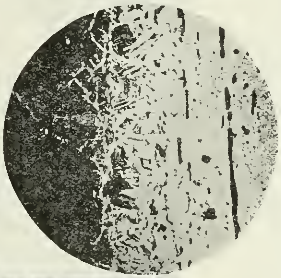


Fig. 2—Section of hand-welded plane iron.



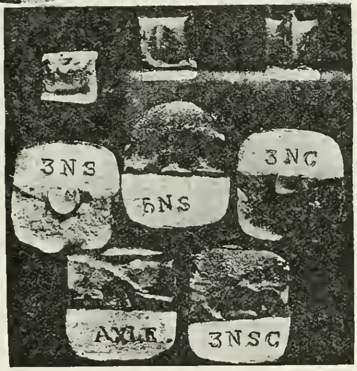


Fig. 3—Fractures of toughened bars showing cores.

In order to flux the scale which forms on heating iron and steel, the blacksmith uses sand. The sand-scale slag thus formed should be such as is fusible at temperatures some hundreds of degrees below the melting point of either the scale or the sand. Its fusibility varies with the respective proportions of scale and sand used. Too much of either constituent produces a less fusible flux. Since the amount of one of the constituents—the scale cannot be determined, the most effective quantity of sand to use can be selected only by skilled judgment; it depends on the amount of scale needing to be fluxed, and the area to be covered by the fusible sheath which cleans the surfaces and shields them from further oxidation.

Being produced under empirical conditions which are so difficult to control, there is no wonder that welds apparently similar are really of varying quality. The best of them are never perfect, though statements to the contrary are frequently made. A weld may appear under certain test conditions to be stronger than the adjacent part, for two reasons: first, because the adjacent parts have been badly overheated and not hammered; and, second, because the welded part has been superficially carburized by the coke fire and to a corresponding extent that part has a higher tensile strength. Both these conditions are due to negligence, and hence, judging from the comparative behavior of welded and adjacent parts under the stress of a tensile test, we arrive at this amazing paradox—the less skilfully the welding is done the better the weld may appear to be.

The tensile test is not a very satisfactory means of recording the weldability of a steel, or the efficiency of a welding process. Although all welds are more or less defective the position of the defect may be unknown, and consequently when a tensile test-piece has been machined it is a question of pure chance whether a particular kind of defect is in the core of the test-piece or on its surface. In the former position the defect may not greatly influence the test figures; in the latter position the test-piece breaks either before, or soon after, the maximum stress has been reached, and consequently the ductility figures are very poor. In the same way the tests made on gun-tube forgings, taken transversely, give very erratic results, due not to variations in the suitability of the material for its intended purpose, but to the occurrence of slag streaks haphazard, now in a favorable position, now in an unfavorable position in the test-piece.

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*From a paper delivered by the author at the annual meeting of the British Iron and Steel Institute May 5 and 6, 1921.

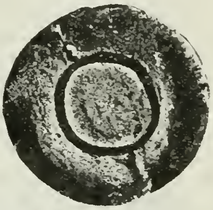


Fig. 4—Fractured tensile piece showing core.

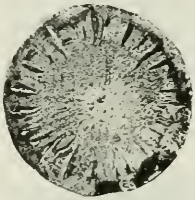


Fig. 5—Fractured tensile piece—no core visible.

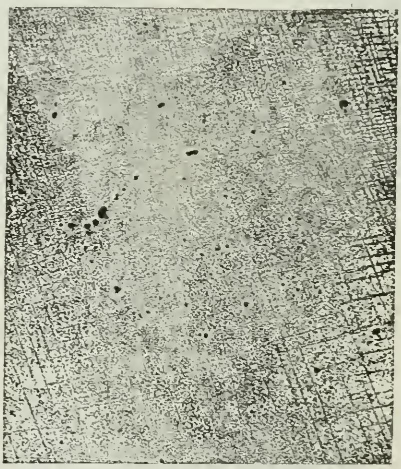


Fig. 6—Unetched micro of 3 per cent nickel steel "B." × 50.

In 1911 a further means of examining welds was described by Dr. Stead. He maintained that "the skillful microscopist can, with absolute certainty, determine whether or not surfaces are welded together, a matter of exceeding importance when considering whether cavities in steel ingots can, or cannot, be welded up." It is quite true that certain differences in welds become clear when sections are examined microscopically. The roll-welded plane iron in Fig. 1 is obviously not so good a weld as the hand-welded plane iron in Fig. 2. It is, however, merely a question of degree. The welded surfaces of Fig. 2 can be torn apart as completely as those of Fig. 1, but it would require a greater effort—neither of them are perfect welds.

How near to perfection a weld can be made is a question of great importance to steelmakers. Under rolling or forging conditions a steel may be unweldable and yet an ingot may be forged into sound bars. If, however, such an ingot be cracked, as more are than we like to admit, then it is not forgable, but will crumble under the hammer. This explains why of certain alloy steel ingots having the same composition some forge well and others not at all, or very badly.

Ingots are never quite free from shrinkage cavities, contraction cavities, cracks or blowholes. It has been proposed that ingots should be made with a volume of deep-seated blowholes sufficient to neutralize piping and thus avoid the necessity of scrapping a discard head. As this method of avoiding pipe has been in use for many years it is fair to assume that such ingots produce billets, bars, and sheets, which are commercially satisfactory for certain purposes. Dr. Stead and others conclude from microscopic evidence "that the welding of blowhole cavities as a rule is complete and perfect." Their experimental evidence is obtained by boring a hole into an ingot or billet, fitting a plug of the same material, sealing the joint with a blowpipe, raising to welding heat and hammering or rolling into a bar. If the bar, when nicked and broken across the welded faces, show no signs of the weld, and the microscopic evidence be satisfactory, it is assumed that the weld has been perfectly made.

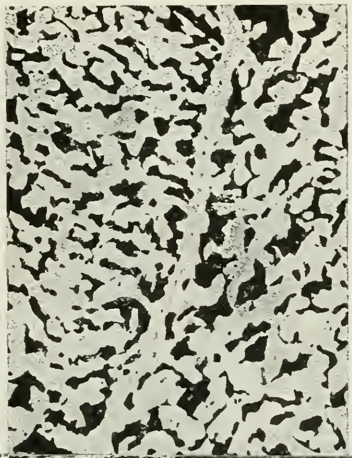
If by perfection we mean a welded joining which is in all respects as good as any unwelded part of the same bar, then it may be said that the evidence is insufficient to support the conclusion even so far as the limited experimental conditions are concerned. The conclusions are a still less satisfactory answer to the question whether blowholes in ingots weld up because a drilled hole is smooth and clean, whereas a shrinkage cavity or blowhole may be uneven lined with segregates, coated with alumina, or otherwise less favorably disposed to weld completely.

During the war great trouble was caused by the occurrence in aero-engine crankshafts of small cracks whose origin was camouflaged by calling them "hair-lines"; just as, 10 or 20 years ago, slag streaks were called "sand cracks" and many other names except slag. The so-called hair-lines arose mainly from ingot defects, notably those occurring in and about the axis of the ingot. These axial defects are the remnants of shrinkage taking place in the nearly solidified ingot. The small volume of impure metal last fluid moves downwards as best it may between the loosely adhering free crystals, filling up shrinkage and contraction cavities as long as it is hot enough, or impure enough, to keep fluid. It is finally frozen in positions, lying like an inverted cone about the axis of the ingot. It is called a "V" segregate because it can be detected by a sulphide print, but the harm lies in the small cavities themselves rather than in the sulphide segregate found in, or near, the cavities.

The "V" cavities are greater when an ingot is cast hot than they are when the same kind of ingot is cast cold. The remedy is to cast cold in a mould tapered as much as is practicable. The remedy, however, does not get rid entirely of the cavities, and one must reckon that the remnants of them may appear either as split centers, if the forging be carelessly done, or as small seams or "hair-lines," however skilfully the forging operation may be carried out.

It has been suggested that minute defects inherent in commercially sound ingots, and small blowholes which may occur accidentally, do not weld up in nickel-chromium steels, because steel containing chromium will not weld. And it has been said that if aero-crankshafts, and other important structural components, were made from nickel steels or, better still, from carbon steels, the greater weldability of these steels would remove all difficulties. When this idea is tested under conditions more favorable than those occurring in practice, i. e., by drilling holes along the axis of a bloom, inserting a machined bar of the same material, and after hermetically sealing the ends, rolling the bloom into a small bar, which is then nicked and broken, we arrive at very curious results. Some steels tested in this way were ordinary mild steels containing 0.15 per cent and 0.35 per cent carbon, a 3 per cent nickel steel, a 5 per cent nickel case-hardening steel, and a nickel-chromium steel, such as was used for aero-engine crankshafts. On etched transverse sections of the bars the weld lines were either not visible or slight indications only were discovered after much patient searching. When the bars were nicked and broken across the welded surfaces all the steels, judging from the fractures, appeared to have welded perfectly except the 0.15 per cent carbon steel and the 5 per cent nickel case-hardening steel. Unless, therefore, we are prepared to believe that tough mild steels weld less perfectly than nickel-chromium steel, we must question the reliability of both these methods of measuring the efficiency of a weld.

Fig. 7—Etched micro of carbon steel "A." × 250.



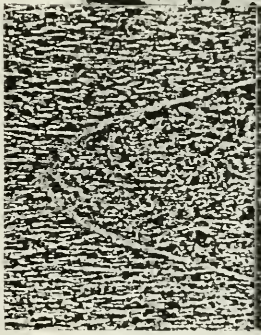


Fig. 8.—Etched micro of 3 per cent nickel steel "B." × 50.

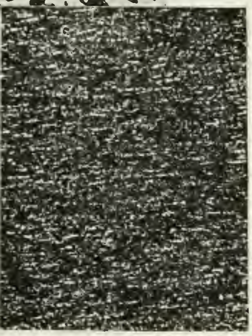


Fig. 9—Etched micro of 3 per cent nickel-chromium steel "D." × 50.

On hardening and reheating the entire series of steels so as to put all of them into a tough condition having Izod figures of over 50 ft.-lbs., we find that not one of them withstands the nicked bar test; without exception they pull apart at the welded surfaces (Fig. 3). These results explain clearly why transverse fractures of nickel steels appear to be more reedy than similar fractures made in ordinary carbon steel, i. e., the nickel steel is tougher and therefore pulls open on the faces of welded blowholes, or slag streaks, more than in the less tough carbon steels; the steel itself is not more reedy in the sense that it contains more slag streaks, or less perfectly-welded blowholes.

It is obviously incorrect to say that steel containing chromium cannot be welded under such conditions as apply to the welding of cavities in ingots. If, however, we are seeking some means of expressing the extent to which such steels weld, as compared with ordinary carbon steel, we should endeavor to state comparative results in concrete figures. No attempt appears to have been made to do this. The method to be described is submitted for consideration in the hope that it may be improved, or a better method may be evolved. Some method, at any rate, is desirable if we are to explain the known difficulties in forging special steel and understand the effects of blowholes and segregates on the properties of steels containing them.

The steels to be examined are prepared as 3½-inch billets. A hole 1 inch in diameter is drilled down the axis of the billet, and a turned bar is driven into it and fused over at each end. The cored billet is then rolled into a bar 4½ inches by ½ inch. The test-piece cut from the side will be broken by a force recorded in foot-pounds which represents the effort required to start a crack at the root of the sharp notch and extend the crack across the specimen. The test-piece cut from the center of the bar is broken in the same way, but it will require a somewhat greater force to extend the crack across the specimen, depending on the perfection of the weld between the core and inside of the hollow billet. If no welding has occurred the crack will come to a dead stop when it reaches the core or leaves it, and a new crack would need to be started in each case. This, as we know, absorbs a great deal more energy than is required to propagate a crack which has been already started.

Very hard steels have low impact values because the material in and about the notch is not able to distort, and such steels, even in the form of cored bars, break readily across whether the weld is a good one or not. Conversely, steels having low impact values, whether they are very hard or not, fracture readily across welded cores, and this explains the insufficiency of the nicked bar test as an indication of good or bad welding. To pull a weld apart, if it can be done, the material should be put into a tough condition. The proposal is to measure the perfection of a weld in terms of the degree of toughness which must be induced in the steel before the weld can be pulled apart.

A series of specimens cut respectively from the edge and center of the flat bar, prepared as described, are hardened and tempered in stages of 100 degrees C. up to say 700 degrees C. These are broken on a standard Izod machine, and the impact value of the edge specimen whose corresponding piece cut from the center is split along the weld is taken as the welding figure. The following examples will explain the working of the process:

Steel A.

Carbon	Silicon	Manganese	Sulphur	Phosphorus
0·34	0·22	0·75	0·052	0·057

Treatment	Degrees C.	Impact Edge Ft.-lbs.	Impact Centre Ft.-lbs.
Oil hardened at 850° C. and tempered at.....	none	7	18
Oil hardened at 850° C. and tempered at.....	100	4	5
Oil hardened at 850° C. and tempered at.....	200	9	12
Oil hardened at 850° C. and tempered at.....	300	3	6
Oil hardened at 850° C. and tempered at.....	400	12	20
Oil hardened at 850° C. and tempered at.....	450	28	48
Oil hardened at 850° C. and tempered at.....	500	44	112
Oil hardened at 850° C. and tempered at.....	550	50	120

Steel B.

Carbon	Silicon	Manganese	Nickel	Chromium
0:34	0·23	0·71	3:26	0:28

Treatment	Degrees C.	Impact Edge Ft.-lbs.	Impact Centre Ft.-lbs.
Oil hardened at 830° C. and tempered at.....	none	3	3
Oil hardened at 830° C. and tempered at.....	100	6	7
Oil hardened at 830° C. and tempered at.....	200	17	16
Oil hardened at 830° C. and tempered at.....	300	4	4
Oil hardened at 830° C. and tempered at.....	400	20	31
Oil hardened at 830° C. and tempered at.....	400	24	32
Oil hardened at 830° C. and tempered at.....	450	23	41
Oil hardened at 830° C. and tempered at.....	450	25	70
Oil hardened at 830° C. and tempered at.....	500	39	120
Oil hardened at 830° C. and tempered at.....	500	39	104

Steel C.

Carbon	Silicon	Manganese	Nickel	Chromium
0·32	0·23	0·53	3:11	0·06

Treatment	Degrees C.	Impact Edge Ft.-lbs.	Impact Centre Ft.-lbs.
Oil hardened at 850° C. and tempered at.....	none	6	15
Oil hardened at 850° C. and tempered at.....	100	10	10
Oil hardened at 850° C. and tempered at.....	200	18	53
Oil hardened at 850° C. and tempered at.....	300	6	8
Oil hardened at 850° C. and tempered at.....	400	30	118
Oil hardened at 850° C. and tempered at.....	450	31	120

Steel D.

Carbon	Silicon	Manganese	Nickel	Chromium
0·35	0·23	0·72	3·57	1:05

Treatment	Degrees C.	Impact Edge Ft.-lbs.	Impact Centre Ft.-lbs.
Oil hardened at 830° C. and tempered at.....	none	2	3
Oil hardened at 830° C. and tempered at.....	100	5	27
Oil hardened at 830° C. and tempered at.....	200	15	120
Oil hardened at 830° C. and tempered at.....	300	4	4
Oil hardened at 830° C. and tempered at.....	400	8	19
Oil hardened at 830° C. and tempered at.....	400	6	20
Oil hardened at 830° C. and tempered at.....	450	14	56
Oil hardened at 830° C. and tempered at.....	500	18	120
Oil hardened at 830° C. and tempered at.....	650	52	120

From these results the comparative welding figure selected would be:

Steel "A" = 28 or rather less
Steel "B" = 20
Steel "C" = 18
Steel "D" = 14 or rather less

That is to say, these figures represent in Izod foot-pounds the degree of toughness which must be induced in the steels by hardening and tempering in order to pull the welded surfaces apart into a visible gap.

If instead of rolling into flat bars the cored billets are rolled into round, or gothic, or square bars, and tensile pieces are prepared from the bars which have been heat-treated to develop maximum toughness in them, the core will sometimes be visible in the broken tensile test-piece, and sometimes not visible. Of the above series of steels, each of which registered a reduction of area of over 60 per cent, all exhibited a fracture like Fig. 4, except steel "C," whose fracture is represented in Fig. 5. This sample of 3 per cent nickel steel had, when tested, a maximum stress of 44 tons, an elongation of 29 per cent on 2 inches by 0.564 inch, and a reduction of area of 65.8 per cent.

For miscroscopic observation a transverse section could be cut from the flat bar on which, if the welded faces were well defined, the core would be represented by the outline of an ellipse. The pointed ends of such an elliptical outline could be traced with more or less certainty in all the specimens, but it was more marked in the alloy steels than in the carbon steels. In Fig. 7 the well-marked outline of steel "B" is represented. After etching, the weld in the carbon steel "A" appeared to be outlined by a band of ferrite such as is represented in Fig. 7 (magnification, 250 diameters). Nothing similar could be detected in the alloy steels in the rolled or hardened and tempered condition.

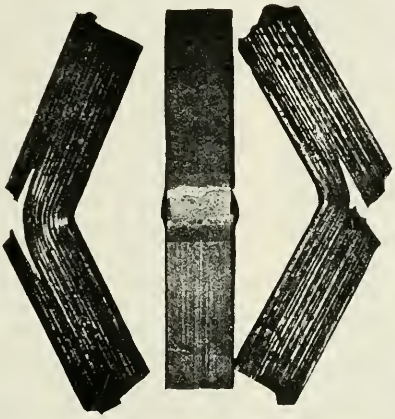
In order to increase the separation of ferrite in the carbon steel and promote its separation, if possible, in the alloy steels, samples of each of the four alloy steels were heated to 860 degrees C. and cooled down to 500 degrees C. in nine to ten hours. Etched sections made from these specimens now showed a band of ferrite about the welded surfaces of all the steels except the nickel-chromium steel. Two photomicrographs are reproduced in Fig. 8 (nickel steel "B") and Fig. 9 (nickel-chrome steel "D").

How far the proposed method of testing welded surfaces, or determining the coefficient of welding, will be found reliable and useful must be shown by further experiment. It is clear, however, that all forms of plastic welding such as are used by the blacksmith, and such as operate in the rolling and forging of piped ingots, produce welded parts unlike other parts of the bar, inasmuch as the welded surfaces can be pulled open, and the free ferrite about them is quite abnormal.

The appearance of free ferrite about welded surfaces recalls the occurrence of the banded ferrite structure in mild steel plates and bars. The banded structure has been ascribed to micro-segregation of phosphorus. On the other hand it has been suggested that non-metallic impurities in steel in the form of slag streaks, etc., act as nuclei around which the ferrite gathers as it falls out of solution, just as sugar candy crystals form about a thread suspended in the liquor. While the formation of free ferrite on the welded faces falls naturally into its place as a special instance of the effect of nuclei action, it is difficult to see how it can be related to phosphide segregation. Referring to Fig. 9 it may be suggested that the limited amount of free ferrite formed under the conditions of cooling was insufficient to form envelopes about both the slag streaks and the welded faces. At any rate it should not be concluded that nickel chromium steels behave exceptionally until lower carbon steels of the same type, or more slowly cooled steels in which free ferrite exists abundantly, have been observed.

The conditions, described in the earlier part of the paper, under which the coefficient of weldability is determined, are obviously empirical, and it would probably be necessary to adhere to given dimensions of billet, the inserted core, and the rolled flat bar in order to get consistent results. To observe the effect of deviations a 4-inch square billet was prepared with the usual 1-inch core, with a half-inch core and with a half-inch hole, the end only of which was plugged. In the rolled flat bar the welded surfaces would of course be a single one in the case of the half-inch plugged hole, and double ones in the cases of the half-inch and 1-inch cores. The welded surfaces would also lie variable distances below the bottom of the notch. The actual figures obtained both on softer and harder steels did not show great variations, and they were all in such directions as might be expected. The effect may be summarized by saying that when the hardened and tempered pieces are sufficiently tough to cause the weld to split open, the impact value obtained from the welded pieces depends on the thickness of metal behind the split weld which has to be bent by the pendulum hammer. In Fig. 10 the right piece represents the half-inch hole specimen and the left piece the 1-inch core specimen. It wou'd clearly require more energy to bend the latter piece than the former after sufficient distortion had occurred to split the welded faces apart. While, therefore, useful information may be obtained whatever size of billet and bar is used, it is advisable to adhere to fixed sizes if the results are required to be strictly comparative. The author prefers to insert a core into the drilled billet, as then two welded surfaces occur in the impact test-piece.

Fig. 10—Broken impact pieces from cored bars.



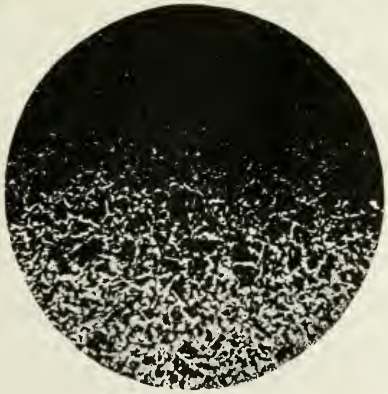
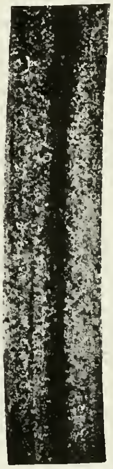


Fig. 12—Photo of machine knife. × 100.

Although we may be convinced that no pipe or cavity in an ingot can be completely welded, we need be neither elated nor depressed by the fact. It is no part of an observer's business to allow personal prejudices or commercial prospects to color his views. An investigator's opinions ought not to be malleable under the stress of convenience. Besides nothing is wholly bad, and what may appear as a defect under one set of circumstances becomes an advantage under another. In this respect we may observe that the degree of imperfection of welds is made manifest by a rise in the impact figure. Were no welding to take place the impact test specimen used would bring the testing machine to a dead stop, although the material was not in a very tough condition. If, therefore, the material of a piped ingot, or a blown ingot, be stressed transversely to the direction in which it has been elongated by forging or rolling, such stresses carried to the point of fracturing will have more work to do than under similar circumstances would be required to fracture such material made from a sound ingot. The plate of a laminated spring is one of the best examples of the truth of this deduction, and as a matter of experiment it is found that a cambered spring plate made from the top of a piped ingot cannot be broken by scragging as easily as a similar plate made from the bottom end of the same ingot. In this sense blown ingots, or those rich in non-metallic impurities, make good spring plates, and it is mainly on this account that Bessemer steel is preferred by many spring makers to the more carefully melted and cast open hearth steel. To some extent the same advantages apply to straight axles, and they are worth consideration even in relation to rolled tyres. It is very remarkable that the fabled virtue of all good wrought iron, viz., its fibre, should be regarded as a defect in steel. It should be valued of course like the grain in wood, according to its direction, in relation to the stresses put upon it.

Fig. 11 Segregated boiler plate.



That pipe, or blowholes, or any other form of cavity in ingots is apt to be, and usually is, associated with segregated carbon, phosphorus, and sulphur, requires no special proof. If, therefore, the discussion be confined to the welding of ingot cavities it would be instructive to know how far the cohesion of the welded surfaces is influenced by carbon, phosphorus, and sulphur respectively, and whether the influence of these elements present in the same specimen is additive or otherwise. A few statements on this subject have been made, but they must be regarded as opinions rather than as evidence. It has been said that "the welding up of blowhole cavities in ordinary practice is, as a rule, complete and perfect," and also that "phosphorus concentration in blowholes facilitates welding, and iron relatively high in phosphorus is more readily welded than very pure material." We must remember, however, that this conclusion depends either on microscopic observation which may be illusory, or on the nicking and breaking method which may be misleading. Of the two methods of judging a weld it is claimed that "nicking and breaking was a more certain method than that of the microscope." As the nicking and breaking method carried out on bars in the forged and rolled condition would lead us to believe that all hardening elements added to steel, including phosphorus, improve its welding properties, its results obviously need to be interpreted with caution.

It is generally stated, without any experimental warrant being adduced, that all segregates existing in ingot cavities decrease the weldability. It has been assumed that in the absence of segregates a perfect weld could be made, and as segregates and imperfect welds are often found together the presence of the segregate and the degree of imperfection are regarded as cause and effect. This conclusion is untenable now we know that perfect welds cannot be made even under the most favored conditions.

In 1912 Dr. Stead prepared two crucible ingots containing 0.020 per cent sulphur. One was blown and the other sound. Both were forged into round bars and parts of each bar were turned into annular rings. When drifts were forced into the rings those made from the blown steel broke with 50 per cent less extension than those made from sound steel. A sulphur print taken from the forged bars showed clearly the location of the blowholes, because segregates had been pressed into them by such forces as operate in every solidifying ingot. The weakness of the one set of rings as compared with the other was ascribed to the presence of sulphide segregates. Such a conclusion, however, is only justified if it can be shown that identical rings made from blown steel containing no segregated sulphide are practically as strong as rings made from sound steel. A direct experiment on these exact lines cannot be made because it is impossible to produce commercial ingots containing blowholes without these holes being more or less lined with segregates. But as the blowholes could not weld completely under any circumstances it is likely that the rings were weaker in one case than the other, quite apart from any question of segregation.

To test this supposition a dozen small holes were drilled lengthwise to a depth of 8 inches into a 4-inch billet. Each hole was cleaned, dried, and filled with petrol vapor before being closed by plugs 1 inch long driven in with a sledge-hammer, and fused over with the oxyacetylene blowpipe. The billet was rolled into a ⅞-inch round bar. From the sound and unsound parts of the round bars annular rings were turned. The rings were drifted, as in Dr. Stead's experiment, until they broke, with the following results:

Steel A. 865.

Carbon	Silicon	Manganese	Sulphur	Phosphorus
0·46	0·15	0·70	0·040	0·030

Condition of Steel	Percentage Increase in Diameter of Drifted Rings made from "Unsound" Part	"Sound" Part
As rolled	2·4	14·5
As rolled	3·4	12·6

Steel Y. 339.

Carbon	Silicon	Manganese	Sulphur	Phosphorus
0·15	0·23	0·92	0·060	0·018

Condition of Steel	Percentage Increase in Diameter of Drifted Rings made from "Unsound" Part	"Sound" Part
As rolled	2·7	20·8
As rolled	7·8	22·9

Sulphur prints were made from both the sound and unsound bars, but there was no distinction between them. These results appear to negative the conclusion that the annular rings in Dr. Stead's experiment broke prematurely on account of sulphide segregation; they would have broken prematurely in any case, because blowholes or any other cavity in an ingot do not weld completely however much work may be put on to the material during forging or rolling.

The difference in behavior between the sound and unsound rings when drifted is a striking example of the disadvantages of blown or piped steel when stressed transversely. Gun tubes or gas cylinders are stressed more or less like the drifted rings, though they are, of course, not made into hollow tubes in the same way, and a welded blowhole would lie more favorably in either case than in the drifted rings. Gun tubes are not made from blown ingots, but blown ingots of mild steel are consciously made into billets and blooms for tubes and gas cylinders. Whatever commercial warrant there may be for this practice it would appear to be undesirable metallurgically, because blowholes induce spot segregates, and are undesirable mechanically because the incompletely welded cavity decreases the resistance of the steel to the working stresses.

There seems to be little doubt that sulphur has been blamed for defects due to other causes, and one wonders whether this segregate in particular is quite as harmful as it is made out to be. Take, for example, a piece of boiler plate which has laminated on flanging. The metallurgist applies a piece of acidified photo paper and produces a sulphur print (Fig. 11), showing that the defective part corresponds with a segregated area. According to text-books segregates are known to be harmful and high sulphur is reputed to cause red-shortness. The inference is easy, but the obvious explanation is, in many cases, not the correct one. It is true that sulphur compounds segregate in steel; so do phosphorus, and so also do carbon compounds. Of these the one most easily detectable, and almost invariably detected, by the method of sulphur printing is sulphur, but it is not therefore necessarily more culpable than either phosphorus or carbon. Further, in perfectly sound ingots (except perhaps very large ones) mass segregation is not possible. In such ingots as are practically sound, that is to say, in the best type of commercial ingots, mass segregates are found only where there are, or have been, cavities. The pipe in a piped ingot is lined with segregates and most cavities in a blown ingot are distinguishable in the forged blooms by the segregates which filled, or partly filled, the cavities in the ingot stage.

On reconsideration of the laminated boiler plate we must regard the dark center part on the sulphur print first as evidence that the ingot material from which the defective article was made was piped. The sulphide segregates enable us to draw this important conclusion, but whether the segregates as a whole have aggravated the defect depends on whether or not they have interfered with the chances of the pipe welding up. The facts are broadly the same with respect to spot segregates. In either case, that is to say, in relation to both axial segregates and spot segregates, the real cause of the trouble is either a pipe or a blowhole, and it is not reasonable to blame the segregate, which in the nature of things gets squeezed into these cavities, unless they interfere with welding. A series of five crucible steel ingots containing from 0.06 per cent to 0.17 per cent sulphur, but otherwise similar in composition, have been prepared in order to observe the influence of sulphur on the welding figure. The results are not ready for publication, but so far as they go they show that either in the rolled condition or in the hardened and tempered condition the high sulphur steels weld as well as, and on the whole rather better than the low sulphur steels. This, and general experience, lead the author to assume that of the segregates themselves, the least harmful, taking all things into account, is probably sulphur. By pure chance it happens to be easily detectable, and it is thus forced to turn king's evidence against its associates.

It would be something of a parodox if, presuming it could be entirely eliminated, sulphur were after all retained in, or purposely added to, steel in order to serve as witness. A sulphur print of an ingot section is one of the best records of the conditions under which an ingot is formed. It may indicate the casting temperature; whether top or bottom casting methods have been used; whether blowholes later filled up have existed earlier in the partly fluid ingot; and many other useful things to the observant investigator. It is by far the most valuable means available for determining whether a forging became axially unsound on hammering or was made from piped material. It indicates at once the presence of spot segregates in forged or machined articles, and either facilitates the machining or suggests that the material should be scrapped, and finally it is an indispensable touchstone for the careful steelmaker who is making steel for such special purposes as rifle barrels. In nearly every case a sulphur print is less valuable as an indication of sulphur than of more harmful things of which its presence gives warning. A sulphur print is worth many sulphur determinations, and we could hardly spare the tell-tale sulphur altogether—we might then have to add sulphur to our steel as we know nothing so voluble, so reliable, and so harmless which would serve the purpose equally well.

Very few experienced observers will doubt the possibility of pulling apart welded faces in objects made from blown ingots. The author believes that it can be done, always providing the steel in which they occur is tough or can be made tough by heat treatment. Iron and steel lumps from which bars for machine knives are made are produced by casting very mild steel against the face of very hot tool steel. In the forged or rolled bar the interpenetration is considerable (see Fig. 12). The two materials, however, can be pulled apart along the original faces. Three-ply steel, such as is used for making plough mould boards, is probably produced in a similar way, but the rolled sheet can be split and the iron core separated if the sheet be first toughened by hardening and tempering.

If a billet be drawn down at one end into a bar the unforged part of the billet may be worked up and down in fluid steel as it rises in an ingot mould, so as to heat the billet and drive off adherent gases. Such a billet may then be left in the upper part of the ingot in a highly preheated and clean condition. After forging that part of the ingot containing the billet may be rolled into flat bars and such bars may be tested. After this procedure a core corresponding with the original billet section may always be separated.

From these considerations one would expect that impact test-pieces cut from the center and from the edge of a flat bar rolled from an ordinary ingot would frequently give different results. Such differences actually exist, and moreover the difference is most marked when the bar is taken from that part of the ingot which is unavoidably least sound. An ingot cast wide end up and provided with an efficient feeder head is—omitting the feeder head—most nearly perfect in its bottom third and top fourth; it is less perfect in the center of its middle half. These facts are clearly discernible in a sulphur print made from a sound ingot which has been sectioned longitudinally through its center. Quite in accordance with the sulphur print indications one finds that variations in impact test-pieces cut from the edge and center of flat bars are greater or less, according as the bars have been made from the middle or one or other extremity of the ingot.

BLAST-FURNACE WORKING AND METEOROLOGY.

The weight of the unit volume of air varies with the atmospheric conditions of temperature, pressure and humidity. A blowing engine working with a constant energy consumption throughout the year will, therefore, not always supply the same amount of air and of oxygen to a blast furnace. With the oxygen percentage the output of a blast furnace is supposed to rise, but the influence of atmospheric fluctuations is not yet fully understood. In "Stahl und Eisen," for October 21 last, Dr. A. Wagner records an attempt to trace that influence by calculating the weight of a cubic metre of air under different meteorological conditions and by analyzing the outputs of Rhenish blast furnaces in different months of the year June, 1913 to 1914. He takes his meteorological data from the meteorological station near Essen. A minimum temperature of — 10 degrees C. and maximum temperatures of + 28 degrees C. — equivalent to a temperature fluctuation of nearly 70 degrees F.—were recorded in January and in May, respectively; Wagner calculates that 14 per cent more air by weight was supplied to the furnaces in the cold January than in the warm May. The pressure fluctuations are smaller, and would in this case only cause 5 per cent. differences in the air weight. As regards humidity, there is absolute moisture (corresponding to the actual vapor pressure) and relative humidity; the latter indicates the percentages of that moisture present which would saturate the air at the particular temperature. The absolute moisture variation is similar to that of the temperature, having a maximum in summer, while the relative humidity varies inversely as the temperature, and is a minimum in summer. The weight of the cubic metre of air was highest (1.283 kg) in January, and lowest in May and June (1.194 kg). The highest air pressures were also observed in January, while the lowest blast pressure and the maximum output seemed to fall in May. No deleterious influence of the high moisture on the coke consumption was observed. James Gayley in 1904 raised the pig output of a furnace, located near Pittsburgh, by 25 per cent (lowering the coke consumption by 19.5 per cent) by drying his air blast, i. e., by cooling it to 5 degrees F. below freezing point. The only experiment made in Germany with freezing the blast proved a failure, and German manufacturers have ascribed Gayley's success to unusual conditions in a rather wasteful furnace.

New Open Hearth Furnaces At Brier Hill

The Blair Engineering Company's Installation Under the Egler Patents—By This Process the Flame is Made a Blow Torch Rather Than a Bunsen Burner.

By GEORGE L. PRENTISS.

AT the meeting of the American Iron & Steel Institute recently, when open-hearth practice in the United States was so carefully and thoroughly discussed, it was admitted that furnace efficiency was altogether too low.

The first duty of the open-hearth superintendent has been to make steel—to come as near as possible towards satisfying apparently insatiable demands.

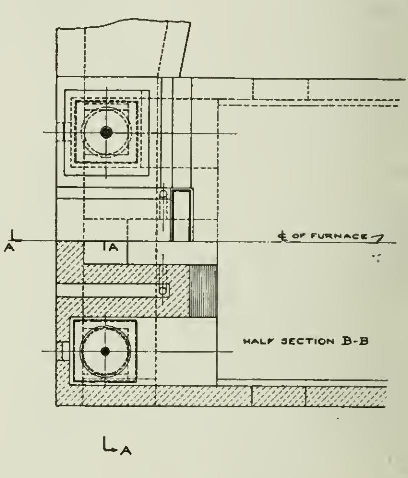
In the Pittsburgh region there was plenty of natural gas—an ideal fuel. Records were hung up long ago which it took hard work to beat. But efficiency received scarcely a thought.

Now with the fuel costs, labor costs and all other kinds of cost high, and likely to stay so, it is natural that the steel industry should turn towards increased efficiency, with a fixed determination to get it. There seems to be two main elements in open-hearth practice, the improvement of which make for increased efficiency. These are furnace design and apparatus for combustion.

Up to the present time there has been little radical change, in design at least, in stationary furnaces. This is necessarily a conservative careful piece of work, for, as everybody knows, small changes bring great differences in results. Still, we must admit that the present furnaces are greatly improved in design over what was thought first-class work a dozen years ago.

In the combustion field, so far as it effects open-hearth furnaces, progress has also been slow. The general plan seemed to be susceptible of but little change, no matter what fuel was used. Whether producer gas, liquid fuel, powdered coal or coke-oven gas, the arrangement for burning the fuel on the hearth has always been planned on the basis of natural or stack draft. This has necessarily involved a theory of combustion which can readily be compared to the operation of the Bunsen burner.

The air and gas are kept separate up to a point where ignition and combustion are to take place, the elements are proportioned so that there is a due excess of air in accordance with a formula, traditional and well nigh sacred. So the area, length, diameter and materials of the fuel ports, uptakes, blocks, etc., have been carefully studied and great pains have been taken



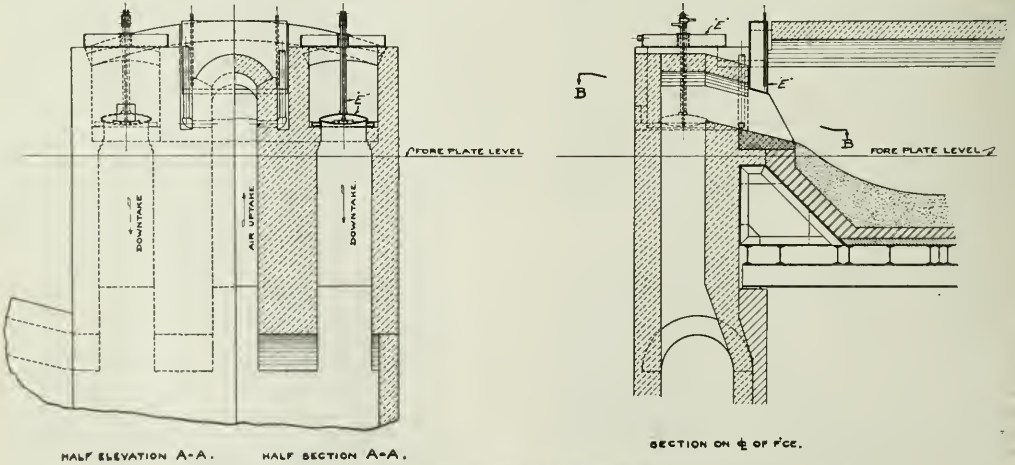


Fig. 1—Egler furnace using coke oven gas, natural gas, tar, oil and powdered coal.

to see that these features, when once determined, are kept in their designed proportion and arrangement as nearly as possible.

It was Mr. Nicholas F. Egler who first saw the advantages of making the flame for the open-hearth furnace a blow torch rather than a Bunsen burner. After some considerable experimental work, he applied for his first patent on this subject in March, 1919. The boldness of his conception as an inventor brought about the usual delays in the Patent Office, and his patent was finally granted in March of this year. The Egler inventions and patents are assigned to and are the property of the Blair Engineering Company.

The first furnaces have been erected and installed at the Brier Hill Steel Company, at Youngstown, and are now operating there with remarkable success. In order to accomplish the results desired, according to the blow-pipe theory, it is necessary that all the gas and air needed for combustion should pass through a port designed as a combined fuel and air port. This also requires in practice positive pressure on both air and gas.

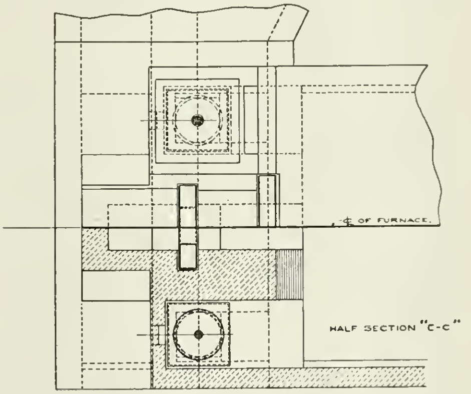
In producer fired furnace practice at Brier Hill, the air is put into the checker chamber by fan pressure, the gas is fed to the gas regenerator at the natural producer pressure which happens to be just right. The gas comes up under the port hood at the end farthest from the hearth and is turned and directed downward towards it in the usual way. At the proper point in its flow towards the hearth the gas meets a stream of air fed vertically upward and across the stream of gas. The air flows all around the gas, below it as well as above it. This stratum of air below the gas is of peculiar advantage in practice.

As soon as the gas and air meet, intense combustion immediately takes place. But such is the speed of the mingled gas and air (partly by pressure given to them but still more by the expansion due to combustion) that the the temperature within the port itself is not found to be unduly high. The ends farthest from the hearth, which might have been expected to suffer by heat radiated into the pocket formed by the abrupt angle at the top of the uptake, have stood up splendidly so far and seem quite likely to last out the full campaign.

The torch of air and gas rushes from the port nozzle in a perfectly mixed flame and the air on the under side of the gas appears to make the flame duck down and hug the surface of the bath in the most satisfactory way.

Combustion is entirely accomplished by the time the middle door of the furnace is passed, and the atmosphere of gas at the outgoing end of the hearth is as clear as the proverbial bell.

The roof is bathed in a slow moving body of air, the surplus over that needed for combustion. This air moves slowly because there is no great excess of air and because it is unable to reach the roof except by detachment from the stream of flaming gas and by the. expansion incident to the heat of the furnace itself. The roofs seem to be in as good condition if not better than normal. The practice at Brier Hill



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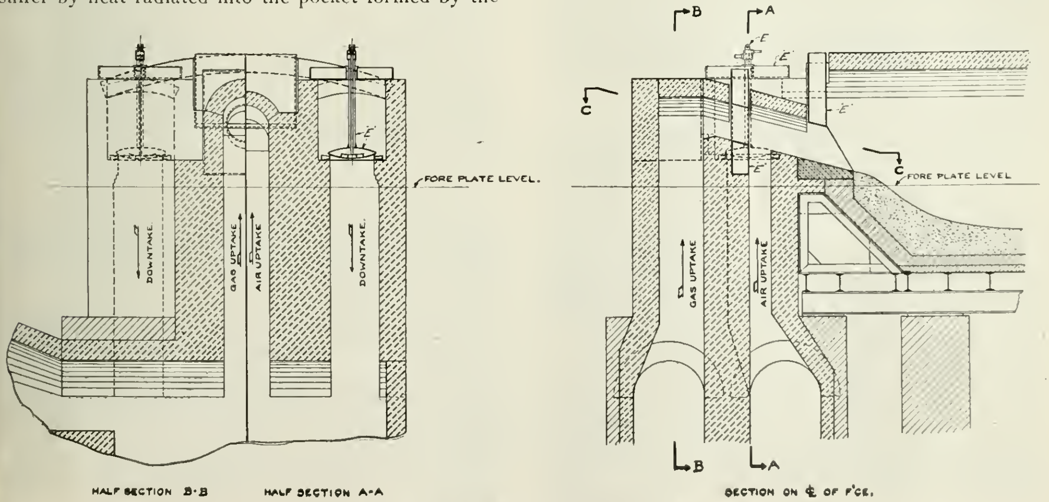

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Fig. 2—Egler furnace using producer gas.

seems to dispose of the theory heretofore held that excess air must be supplied in considerable volume to take care of the roof and walls. Until Egler's furnace was built, nobody has ventured to eliminate this feature.

At each end of the furnace are two flues auxiliary to the main gas and air supply. These flues at the upper or furnace end of their uptakes are fitted with water-cooled mushroom valves on water-cooled seats. At the end where the gas is entering, these valves are tightly closed and the flues they cover (which are filled with air from the air regenerators) cannot discharge any air into the furnace. All must pass through the combined fuel and air port.

At the discharge end of the furnace these auxiliary valves are wide open and the valves themselves are drawn up into pockets provided in the furnace roof. The auxiliary flues thus uncovered permit the gases of combustion, now greatly expanded, to flow from the furnace to the regenerators. There are thus four outlet flues in use, two under the hood of the outlet port (one to gas checkers and one to air) and the two auxiliary flues which are both connected to the air regenerators.

The furnace is, of course, reversed from time to time in the usual manner. The mushroom valves are simultaneously reversed also. No interruption or slackening of furnace heat is noticed on reversal. A noteworthy feature about these mushroom valves is the ease with which the valves and seats can be cleaned through an inspection door in the side wall directly opposite each valve. Observation of actual practice shows that the cleaning off of a valve seat takes only a couple of minutes, and may be done with a short-handled tool. The seats are customarily cleaned off once or twice a day, so the valves remain entirely tight.

Observations in the checker chambers show that while they are quite hot enough, they are in nowise overheated, notwithstanding the heat on the hearth. It may be stated that the hearth temperature is the highest ever systematically maintained. Observers agree that they have never seen anything like it. But the combustion is so perfect and the heat transmitted to the bath so greatly in advance of previous practice, that the checkers stand at about 2,000 degrees F. all the time, inlet gas is about 1,500 degrees F. and the stack temperatures run constantly from 700 to 800 degrees F.

The waste heat boiler is thus a superfluity, and probably no steel man will lament its passage to the limbo of forgotten things.

Stack draft is necessarily low with such low stack temperatures.

These remarkable conditions of combustion are reflected not only in the economy of the furnace, but in its capacity as well. Records are too new to be given out as yet, but they will be eagerly awaited when a representative campaign has been run.

The Egler furnace is equally well adapted to all kinds of gas or liquid fuel, and to powdered coal. Other furnaces at Brier Hill will afford the opportunity to judge of the performance with natural gas and with coke-oven gas (with and without tar) and on liquid fuel alone. The installation for coke-oven gas and for natural gas differs from that above described on producer gas, in the following particulars:

There is only one set of regenerators, the air uptake is farthest from the hearth instead of nearest (as with producer gas), the gas is admitted at a point between the air uptake and the port outlet to the furnace by the customary pipes, one on each side of the combined fuel and air port, and the supply pipe outlets are so located and directed as to insure the most complete mixture of gas and air. Otherwise the furnace installations are the same; the mushroom valve arrangements are identical, and the whole theory of combustion is, as above described, strictly adhered to.

For liquid fuel the installation is similar to that for coke-oven gas. The oil or tar is admitted through the end wall beneath the hood of the port which thus becomes a perfect retort, giving the liquid to the hearth in a state of complete gasification.

The use of coke-oven gas in combustion with oil or tar is provided for in this manner by the most simple and easily operated construction, equally efficient with either or both types of fuel.

For powdered coal, the installation is also similar to that for coke-oven gas, except that the application of the coal fuel to the retort formed by the combined fuel and air port is dependent upon the type of powdered coal supply with which the steel plant may be provided. Where powdered coal is the indicated fuel but has not been installed previous to the equipment with the Egler furnace, the arrangements for combustion are extremely simple. The retort is used also as a diffusion chamber, and especially constructed for that purpose.

It is expected that further data on this subject will be available to the industry at no distant date.

It seems evident that phenomenal increase in capacity and economy by the use of the Egler invention are assured, and also that open-hearth furnace construction costs are likely to be considerably reduced by its installation. It is already evident that brick materials can be used of cheaper grades than at present in several important parts of the furnace installation. This also is a subject which the future practice must confirm before positive statements can be made.

The drawings accompanying this description will clearly show the essential features of the Egler furnace. It is obvious that for special conditions a considerable variation in the details of the installation can be easily made.

The twenty-fourth annual meeting of the American Society for Testing Materials will be held at Asbury Park, N. J., June 20 to 24, 1921. Following is a summary of the program:

Committee Meetings — Monday afternoon and evening, June 20; Wednesday afternoon, June 22.

Business Meetings—Tuesday, June 21, 10 A. M., 3 P. M. and 8:30 P. M.; Wednesday, June 22, 9:30 A. M. and 8 P. M.; Thursday, June 23, 9:30 A. M., 3 P. M. and 8 P. M.; Friday, June 24, 9:30 A. M. and 8 P. M.

Special Features — Informal dance and smoker, Tuesday evening; annual golf tournament, Friday afternoon.

The McKune System for Open Hearth

Some Drawings Showing Various Installations of the McKune System Which Have Been Successfully Operated—Advantages of the McKune System Enumerated.

By P. S. YOUNG,
Open Hearth Superintendent.

THE only way to obtain results in trying out a new method for an open hearth is to work the method under circumstances and conditions similar to these on the furnaces where the operation is successful. To work a forced draught successfully it is essential to have a limited area in the uptake or a cage in front of the burner or the blow-torch principle is lost. It is also necessary to have sufficient area at the outgoing end of the furnace to handle the products of combustion at a stack draught speed which is lower, of course, than that induced by fan pressure. In a reverbatory furnace, therefore, some check or damper has to be inserted in the incoming end. Therein lies the principle of the whole construction of the McKune system, which has proven successful on many types of furnaces, and is showing itself more successful every day. It cuts the wastages of fuel to a minimum, increases the flame temperature over the bath, gives a better flame control, and prevents the wear on the body of the furnace and also on the outgoing end. It prevents over-oxidization to a great extent, and as it cuts down the time of the heat it has the effect of keeping the sulphur out of the bath, where a high sulphur fuel is used.

The McKune system may be applied to furnaces using any fuel, though it was originally designed to overcome the difficulties of burning de-benzolized by-product gas. In the burning of de-benzolized by-product gas Mr. McKune used a producer gas construction, and introduced the gas by side burners into the gas port of the furnace. Over the port are openings coming from the side uptakes, as shown in Fig. 1. These uptakes are blocked off by water-cooled dampers at the incoming end. The dampers are set laterally in the uptakes and entirely shut them off. The third uptake is the only one through which air is introduced to burn with the fuel. This uptake is connected by openings through the chamber walls so that it is connected to both checker chambers, and through the air intake valve fan air is introduced at about three static inches pressure. This meets in the port with the gas at eight ounces pressure and burns as it leaves the port. The mixture may be so carefully adjusted and controlled and the flame temperature raised to such a high degree, that a short flame only extending to the middle door is all that is necessary for the rapid melting and working of a heat. Not only is complete combustion and better control of the flame insured, but oxidization of the stock in the bath is greatly minimized and the introduction of nitrogen to the bath is reduced. By the use of de-benzolized gas, the cleanness of the gas itself is a pertinent feature and the dirt carried over into the checkers is so scarce that the checkers easily outlive the furnace. The velocity of the flame leaving the port not only means better flame control, but also better conduction of heat to the bath. As the flame is short, the outgoing corners and port are not punished as they are with a longer, colder flame. With three downtakes to take care of the products of combustion, there is no fear that there will not be a plentiful area of escape for these to the checkers. Mr. McKune cut down his repairs more than one-half on this system in his plant, and found his cinder pockets to contain less than two feet of slag at the end of the furnace campaign.

Where there is not room between the turnaces to allow for the lateral type of slide damper, and where it is still desired to get the advantages of pressure air and the blow-torch style of burner, the movable port arrangement has been designed to fulfill these conditions. In this system a water-cooled damper or "cage" operates through the port roof and shuts off the whole inner orifice of the port, except for a hole which is in the center of the damper. In Fig. 2 will be seen this damper arrangement and the hole will be noted to be 24 inches in diameter. It is the view of the author that this might well be flattened out to a distinct lateral oval, with perhaps better results, as it would be more inclined to flatten and spread the flame which would then impinge on a greater surface of the bath. By inclining the burner so that the fuel would barely brush the bottom of the oval, the fuel would be certain to come in direct contact with the bath and any excess air would be above and at the sides of the flame, thus forming an insulator to attacks on the roof, back wall and front wall of the furnace. By means of this damper, the size of the port may be designed amply large for the exit of the outgoing gases. The damper itself is water-cooled and bricked on both sides. In case it should need repairs, it can be easily drawn up through the slot in the roof and a spare inserted. This type of damper could be used to great advantage in the burning of tar, oil, or pulverized coal, for all of which purposes it seems to be admirably adapted. It can also be observed that this damper can replace necks in the furnace, in this manner, that the damper can be left hanging partway into the furnace if the fuel is seen to rise to the outgoing end. With the fuels mentioned above, it will fill a long sought need, in that the sulphur content of the fuel has been a serious drawback in steel manufacture, and the shorter the time of the heat the less the bath will be in association with the fuels. Anything, therefore, that speeds up the making of steel by better combustion of these fuels is of interest metallurgically. We have long thought that powdered coal as a metallurgical fuel had its good points as well as its drawbacks, and a system of this kind may be the essential step necessary to establish it as one of the leading fuels for open hearth furnaces. As a fuel it is the cheapest obtainable, the cost of installation is not great, and with oil, gas, and good gas coal at a premium and harder to obtain year by year, the day may come when powdered coal will have to be considered more seriously than it is at present. Not every steel plant can arrange to have its own by-product plant, and pulverized coal will have to come into its own. With a method of combustion efficiently worked out like that of the McKune-Danforth system, we believe that pulverized coal can be burned without choking the checkers, and without burning down the furnace, and, what is more, without the great rise in sulphur which it has so far shown in operation on open hearth furnaces.

The method of raising and lowering these dampers

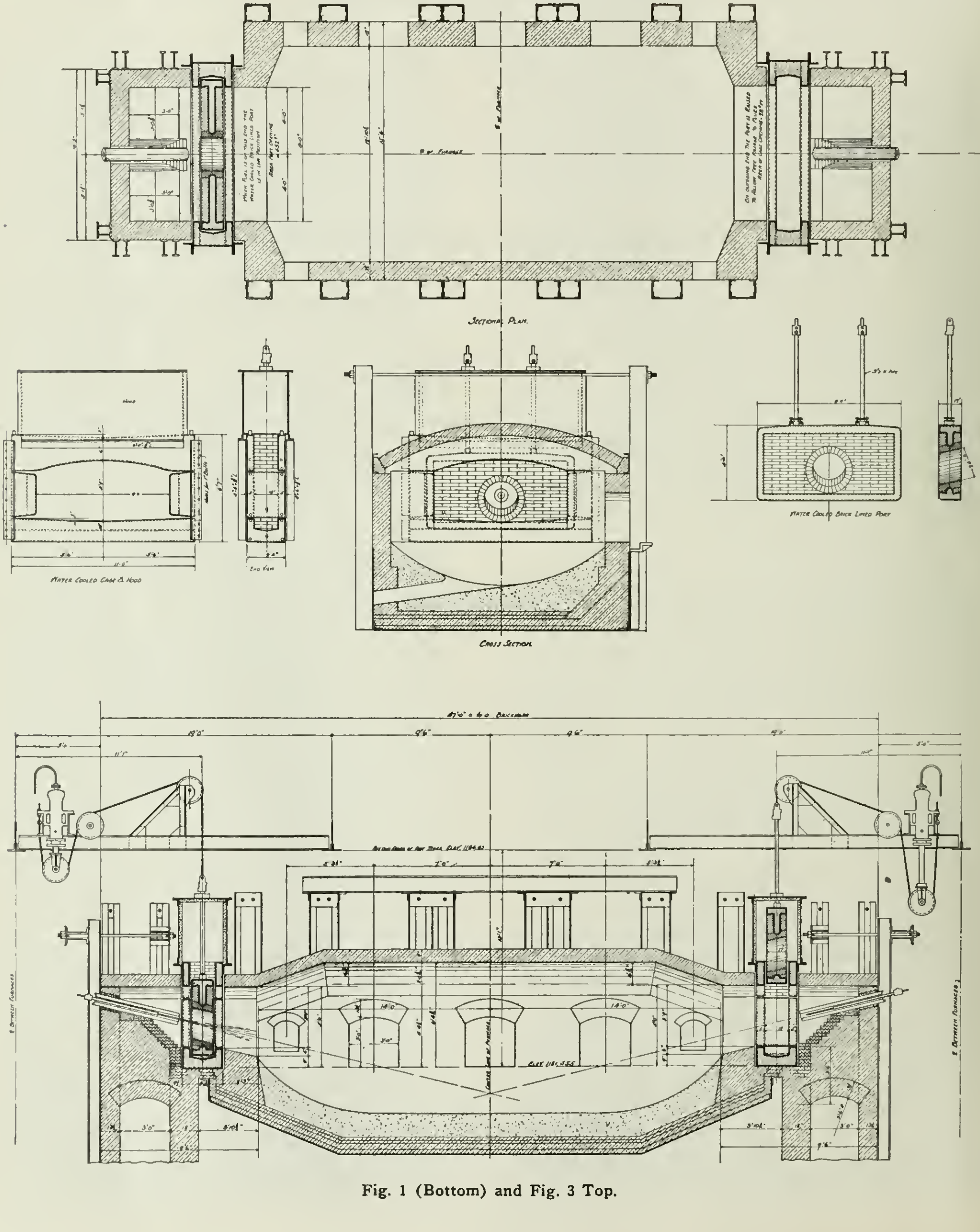
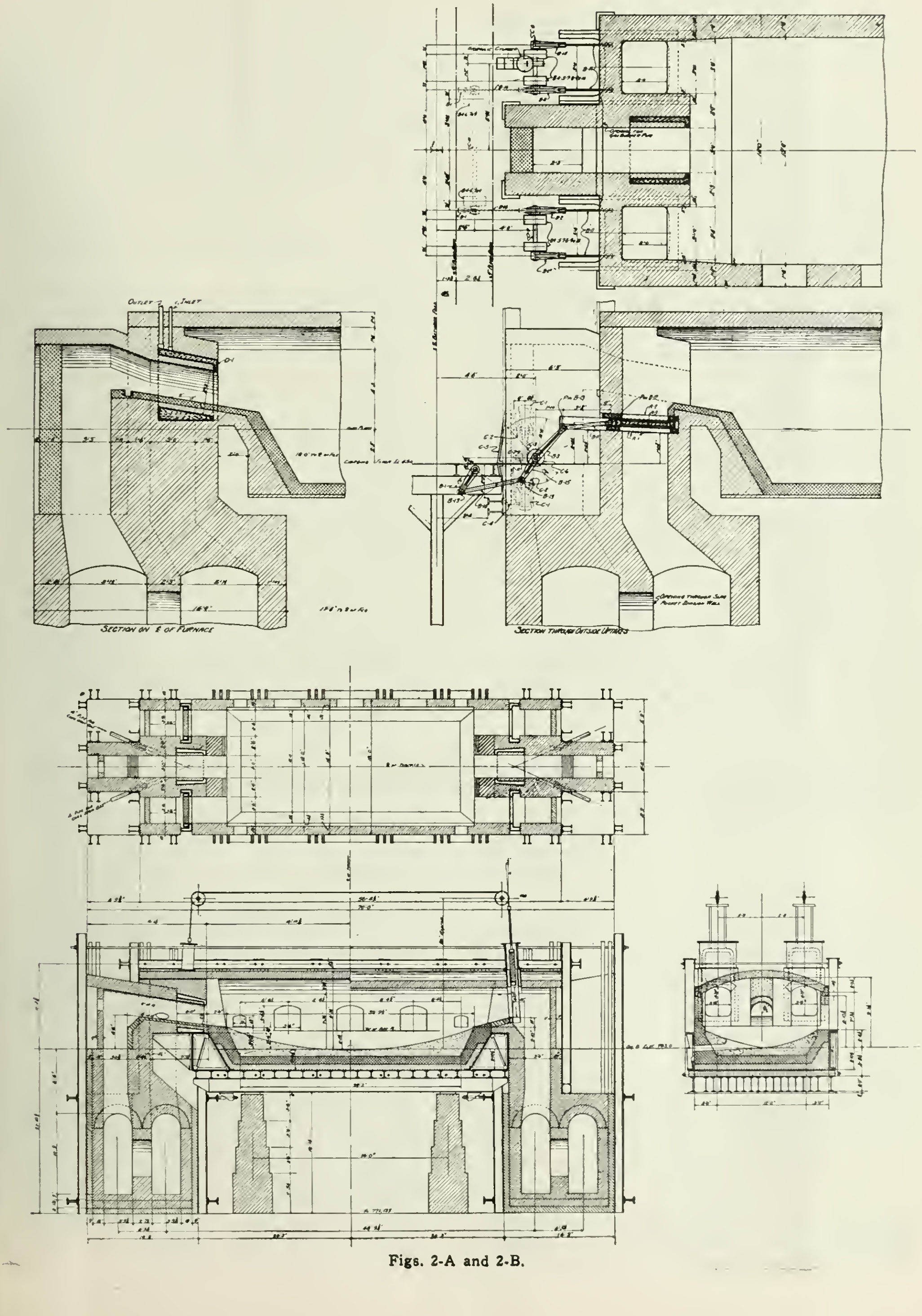


Fig. 1 (Bottom) and Fig. 3 Top.



Figs. 2-A and 2-B.

through the port roof is by means of a motor in conjunction with counterbalancing weights placed over the furnace roof. This puts the mechanism out of the way.

In Fig. 3 is shown another method of construction for use in burning by-product gas. In the original McKune system the gas was introduced into the port by pipes from the side in a slot or gas box, as natural gas is usually introduced. In this construction the coke oven gas is brought in through two converging burners which allows the fuel from the two burners to meet over the port. The air is blown in through a central uptake, and the two side uptakes are blocked off by slope dampers, almost vertical. The dampers at the other end are of course raised as in the other constructions of this system, and the arrangement for raising and lowering the dampers is like that previously mentioned. This, to our mind, is a still better way than the lateral dampers in the uptakes, as it performs the same functions and does not need the space between the furnaces that is required by the other system. In this system the gas can, of course, be introduced by a gas box as well as by the converging burners. Special care should be observed in building up the points of the monkey walls marked A and A′, B and B′, and water coolers might be inserted here to advantage.

The system for burning producer gas with pressure air is here shown. It is called the horseshoe port arrangement, and shows a method very similar to that just described. The air coming under pressure through outer horseshoe makes an intimate mixture with the gas coming through the inner horseshoe and directs the course of the gas as well as giving maximum efficiency in the combustion of the fuel. It is a splendid application of the McKune system and should utilize every foot of the producer gas. Producer gas has always had a great waste in furnaces, and has even been perniciously wasted, as the personal element in its waste often enters into the discussion of its abuse as a fuel. The melters always blame an excess use to the fact that the gas was not rich enough, or not supplied to them at the right time at the proper steam pressure, and the gas producer operators have their alibis to oppose the melters' testimony. Anything which will aid in the operation of the furnace and will render the gas more easily controlled will help this condition, and we feel that this system should do just this thing.

To sum up the advantages of the McKune system, we find:

1. Better combustion. Due to more intimate mixture of the air under pressure with the gas or liquid fuel in the incoming port.
2. Better flame control. Due to the fact that the orifice out of which the fuel is emerging is small, the speed of the flame from the port is increased and the easier control of the feeding of the fuel and air is facilitated.
3. Less wear on the furnace proper. Due to better flame control, and also due to the fact that the flame being hotter can be shorter, therefore not punishing the outgoing end. Also due to the construction allowing for ample space to have products of combustion removed.
4. More heats per furnace. Due to three points mentioned above, and the fact that the heats should be produced in better time. Also due to the fact that properly burned fuels will not clog the checkers.
5. Less oxidation in bath. Due to better time on heats, absence of excess air in great quantities as was necessary without intimate mixture caused by pressure air.
6. Less nitrogen in bath. Same reason.
7. Less rise in sulphur. Same reason, and due to better combustion of high sulphur fuels.

N. B.—This is not an advertisement for the McKune system. The author has never been, is not, and does not expect to be in the employ of the Blaw-Knox Company. He is, however, indebted to them for some of the prints and tables, which were secured at his own request by the courtsey of the engineering department of Blaw-Knox. He is convinced that the above methods of operation are of revolutionary importance in the manufacture of open hearth steel.

Analysis of Wholesale Electric Costs

Graphic Charts Which Facilitate the Analysis of Light and Power Costs.

By F. M. VAN DEVENTER.

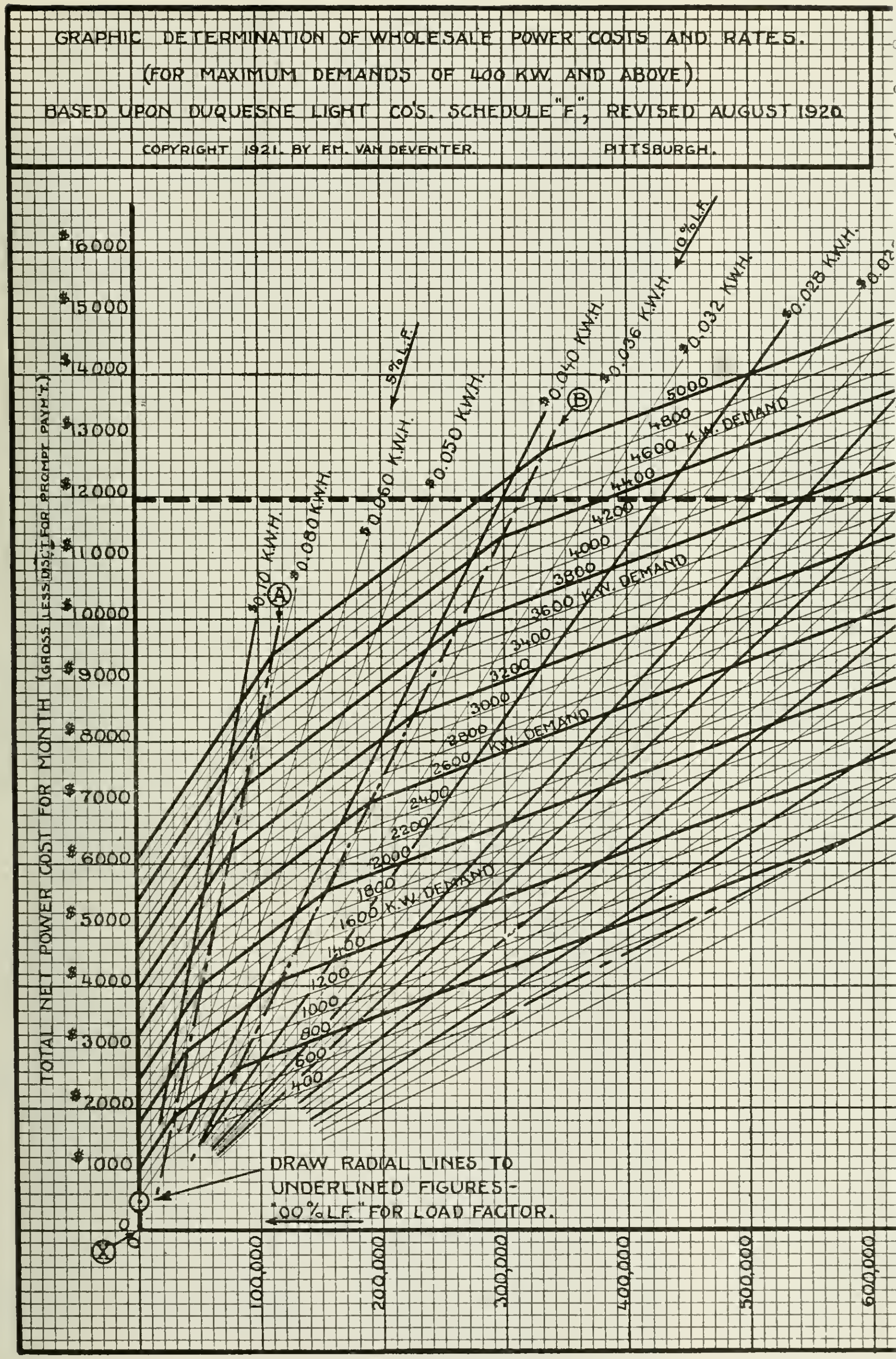
Synopsis: This subject will be treated in a series of three articles. The present one embodies a graphic chart which is designed to facilitate the determination of total cost and unit rate for power purchased under Duquesne Light Company's wholesale light and power schedule "F," for demands of 400 kw and greater. The article contains an explanation of the chart and of one of it's principal uses. The second article will present a similar chart for the West Penn Power Company's wholesale power schedule "J." The third article will embody a general consideration of the "demand plus energy" system of rates, and an analysis of the consumers' power conditions which affect the cost of the service.

ARTICLE I

WHEN power was purchased under a unit rate per kw-hour, the rate being a definitely fixed quantity for each user depending upon whether he were a small domestic consumer or a purchaser of power in "wholesale lots," it was an easy matter to check the monthly charge for power, by merely multiplying the quantity of energy metered by the unit rate. Similarly an estimator or engineer who was confronted with a problem which involved the power charge for operating a piece of proposed equipment knew what the unit energy rate would be, without any calculation.

The present-day "demand plus energy" schedules, however, entail considerable complication, as the unit rate to a particular consumer changes from one month to the next, depending upon the nature of the load curve; and a more or less extensive calculation must be made to check a power bill or to determine the unit rate under any assumed condition.

The Duquesne Light Company's schedule "F" for wholesale light and power is a good example of this type of contract. The several paragraphs which fix the cost of service are essentially as follows:



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Y BLOCKS

3,000 kw.
400
2,600
52,000
19,400
71,400 kwh. (A)
142,800 kwh. (B)
214,200
535,800 kwh. (C)

OST

170.00
3,480.00
$ 3,650.00
14.00
2,278.40
2,284.80
4,018.50
8,595.70
$ 12,245.70
1.00
142.40
142.80
286.20
$ 11,959.50

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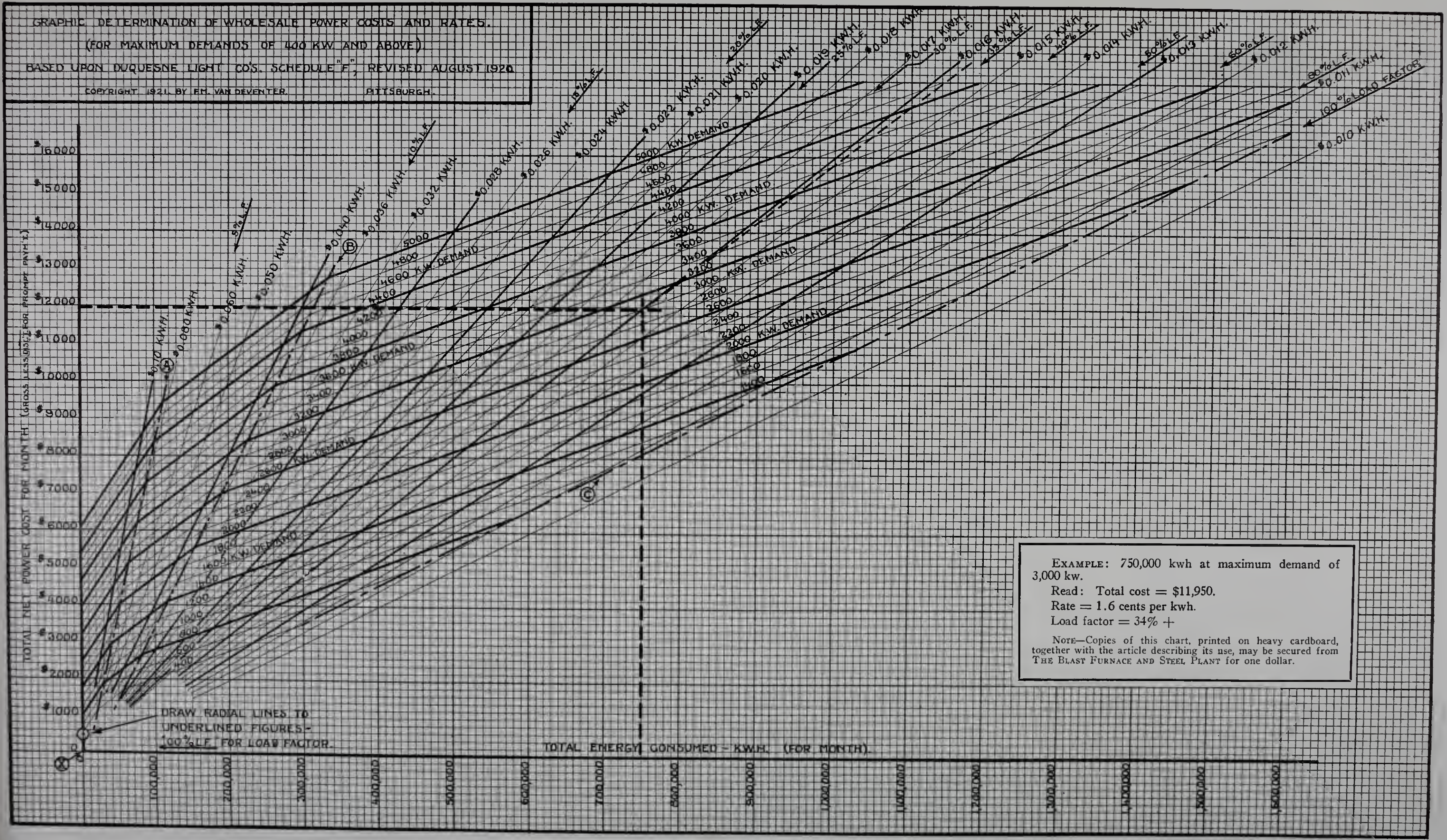

GRAPHIC DETERMINATION OF WHOLESALE POWER COSTS AND RATES.

(FOR MAXIMUM DEMANDS OF 400 KW. AND ABOVE)

BASED UPON DUQUESNE LIGHT CO'S. SCHEDULE "F", REVISED AUGUST 1920

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Example: 750,000 kwh at maximum demand of 3,000 kw.

Read: Total cost = $11,950.

Rate = 1.6 cents per kwh.

Load factor = 34% +

Note—Copies of this chart, printed on heavy cardboard, together with the article describing its use, may be secured from The Blast Furnace and Steel Plant for one dollar.

RATE

DEMAND CHARGE

For the first 100 kw of demand, $1.70 per month per kw.

For each kw of demand in excess of 100 kw, $1.20 per month per kw.

ENERGY CHARGE

For the first 200 kw-hours of the first step or quantity block of energy delivered each month, for each demand, 70 mills per kw-hour.

For the balance of the first step or quantity block of energy delivered each month, for each demand, 32 mills per kw-hour.

For the second step or quantity block of energy delivered each month, for each demand, 16 mills per kw-hour.

For all energy delivered each month in excess of these quantities, 7½ mills per kw-hour.

DISCOUNTS

For payment of bills within 10 days from date thereof:

Five mills per kw-hour for all energy billed at 70 mills per kw-hour.

Two mills per kw-hour for all energy billed at 32 mills per kw-hour.

One mill per kw-hour for all energy billed at 16 mills per kw-hour.

No discount will be allowed on energy billed at 7½ mills per kw-hour.

For High Tension Service—

Five per cent on gross bills where customers have a contracted demand of 1,000 kw or more and where customers furnish sub-station buildings and install necessary equipment in accordance with the company's specifications and employ a skilled attendant to operate same.

DETERMINATION OF DEMAND

Demand shall be taken as 75 per cent of the connected load except where determined by measurement.

Demands may be determined by measurement from time to time at the option of either party, but the demand contracted for shall not be decreased during the terms of the contract.

*Demand meters are now used universally by the Duquesne Light Company where the demand is greater than 400 kw, and in most cases where it is less than 400 kw.

. . . .

MINIMUM CHARGE

The minimum monthly payment shall be an amount equal to the demand charge for 75 per cent of the connected load.

TERM

Contracts shall be written for terms of not less than one year.

SPECIAL TERMS AND CONDITIONS

High tension service shall be 11,000, 22,000 or 66,000 volts, and will be supplied only where the company has this service available without any extension to its present transmission system.

Wherever direct current is available, it will be furnished at an advance of 30 per cent on the gross energy charges in this rate.

Where the power factor of the customer's load is below the subjoined schedule of permissible power factors the company reserves the right to increase the demand as estimated or measured in the ratio that the actual power factor as determined by test bears to the permissible power factor.

75% power-factor for demands from 20 to 50 kw.
80% power-factor for demands from 51 to 250 kw.
85% power-factor for demands from 251 to 1,000 kw.
90% power-factor for demands above 1,000 kw.

BASIS FOR DETERMINING STEPS OR QUANTITY BLOCKS FOR ALL DEMANDS

. . . .

401 KILOWATTS DEMAND AND OVER

To obtain the first step or quantity block of energy for demands of 401 kw and over, add one (1) per cent of 2,000 or 20 kw-hours for each additional kw of demand in excess of 400 to the first step (19,400 kw-hours) of the 400 kw demand; the second step or quantity block of energy for each demand shall be two times that of the first step or quantity block of such demand.

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*Author's note.

PROBLEM A.

An example of the standard method of calculation follows:

Determine the cost of 750,000 kw-hours at a maximum demand of 3,000 kw.

DETERMINATION OF QUANTITY BLOCKS

First block:	
Demand =	3,000 kw.
Subtract 400	400
	2,600
2,600 × 20 =	52,000
Plus 19,400	19,400
First block =	71,400 kwh. (A)
Second block:	
71,400 × 2 =	142,800 kwh. (B)
Third block (remainder):	
Sum of first and second blocks =	214,200
750,000 — 214,200 =	535,800 kwh. (C)

DETERMINATION OF COST

Demand charge:		
First 100 kw demand at $1.70 =	$ 170.00	
2,900 kw (remainder) at $1.20 =	3,480.00	
Total demand charge =		$ 3,650.00
Energy charge:		
First 200 kwh at $.070 =	$ 14.00	
Next 71,200 kwh at $.032 =	2,278.40	
Next 142,800 kwh at $.016 =	2,284.80	
535,800 kwh (remainder) at $.0075 =	4,018.50	
Total energy charge =		8,595.70
Total gross power cost =		$ 12,245.70
Discount:		
200 kwh at $.005 =	$ 1.00	
71,200 kwh at $.002 =	142.40	
142,800 kwh at $.001 =	142.80	
Total discount =		286.20
Total net power cost		$ 11,959.50

Equation Form.

The complicated wording of the contract can be stated much more simply in equation form; but the amount of calculation required is the same by either method. One short cut can be made by applying the discount reduction to the basic block rates, by substituting 65 mills, 30 mills, and 15 mills, for 70 mills, 32 mills, and 16 mills respectively. As the Power Companies show both gross and net amounts on their bills, they do not use this short cut.

The following equations are for *net* costs only as the discount has been deducted as just described:

Let D represent maximum demand, kw. (either the contracted demand or the maximum value determined from a recording demand meter).

Let A represent the number of kwh in the first quantity block.

Let B represent the number of kwh in the second quantity block.

Let C represent the number of kwh in the third quantity block, (this being the difference between the total consumption and the sum of the first and second blocks).

Then:

Demand charge = [(D — 100) × $1.20] + $170.00
A = 19,400 + [(D — 400) × 20] kwh
B = [2 × A] kwh
C = total kwh consumed minus (A + B)
Charge for A = [(A — 200) × $.030] + $13.00

Charge for B = B × $.015
Charge for C = C × $.0075
Total net charge = demand charge plus the sum of the energy charges for A, B and C.

Graphic Determination of Cost.

The accompanying chart was designed with two purposes in view. First, to facilitate the checking of power bills (for demands of 400 kw and greater), by means of a chart instead of by calculation; and second to put the conditions of the contract into such form as to allow a vizualization of the terms, and of the effects of the several factors which affect the cost of the service. The latter phase will be reserved for the third article. The first phase will be demonstrated after the construction and use of the chart have been explained.

There are five variables represented on the chart; kwh consumed, monthly power cost, demand, rate per kwh and load factor. Each variable is represented by a "family" of lines, and if any two of the five variables are known, the intersection of the lines representing the particular values of the variables determines at once the other three variables. Vertical lines are lines of constant energy consumption; horizontals are constant monthly costs; constant demand lines are parallel to each other and have a slope of about 20 degrees in the major portion of the chart. The constant unit rate lines are radii from the intersection "X" at the lower left-hand corner of the chart, and are marked, e. g. "$0.011 (per) kwh." The constant load factor* lines are also radial, but it is unfortunate that their center is so near, and yet not coincident with the center of the other radial lines. For this reason these lines are not drawn on the chart, but are indicated by, e, g. "20% L. F." ← which indicates that the 20% load factor line lies between the arrow and the circle just above the point "X." A ruler or other straight edge may be placed to represent any load factor line, but it is suggested that if the user of the chart makes frequent reference to this variable, that the lines be drawn with red ink.

Three other lines are significant. The dot and dash lines "A" and "B" mark the divisions between the first and second, and the second and third quantity blocks respectively. Their use will appear in problem "B." Line "C" is the 100 per cent load factor line and marks the boundary of the chart, because in this particular case the average demand is the maximum demand maintained continuously over the entire month. The $.010 per kwh line is drawn, even though it lies outside the possible range of conditions, merely to show that no condition can bring the rate down to that figure under this schedule.

EXAMPLE

For a working example in the use of the chart, suppose the following bill is rendered, and is to be checked:

TOTAL CONSUMPTION	=	750,000
200 kw-hours at 7.0c	=	$ 14.00
71,200 kw-hours at 3.2c	=	2,278.40
142,800 kw-hours at 1.6c	=	2,284.80
535,800 kw-hours at .75c	=	4,018.50
Plus 30% Direct Current	=	
Monthly Service Charge	=	3,650.00
TOTAL		12,245.70
Less 5% for High Tension Service................		
A discount of { .005 on 200 kw-hours .002 on 71,200 kw-hours .001 on 142,800 kw-hours } or		286.20
will be allowed if paid on or before		
Net		$11,959.50

Your demand was taken by measure and was found to be 3,000 kw. This bill is rendered on that basis.

(It will be noted that this is the same as Problem A).

The given conditions are: 750,000 kwh and 3,000 kw maximum demand. Starting at 750,000 kwh on the lower scale (energy consumed) follow vertically until the 3,000 kw demand line is intersected. This intersection determines the significant point from which all the unknown variables may be determined. Following horizontally to the left, the power bill is found to be about $11,950.00, which is a good check on the $11,959.50 bill as rendered. If the unit rate is desired, it is seen that the significant point falls exactly on the $0.016 line; hence that is the cost per kw-hour. Further, a straight edge placed between the circle near point "X" and "35% L. F." ← passes slightly to the right of the significant point, hence the monthly load factor was 34% +.

PROBLEM B.

The location of an error when a bill does not check is demonstrated by the following:

TOTAL CONSUMPTION	=	520,000
200 kw-hours at 7.0c	=	$ 14.00
63,200 kw-hours at 3.2c	=	2,022.40
126,800 kw-hours at 1.6c	=	2,016.80
329,800 kw-hours at .75c	=	2,473.50
Plus 30% Direct Current	=	
Monthly Service Charge	=	1,850.00
TOTAL........................		8,376.70
Less 5% for High Tension Service................		
A discount of { .005 on 200 kw-hours .002 on 63,200 kw-hours .001 on 126,800 kw-hours } or		254.20
will be allowed if paid on or before		
Net		8,122.50

Your demand was taken by measure and was found to be 1,500 kw. This bill is rendered on that basis.

By the chart it is determined that the cost is about $7,300.00, which indicates that the bill of $8,122.50 as rendered, is about $800.00 high.

The demand or service charge is found from the chart by following the imaginary 1,500 kw demand line (midway between 1,400 and 1,600) back to the vertical major axis, where the value $1,900.00 is estimated. As this agrees approximately with the $1,850.00 as billed, this may be assumed to be correct. To determine the number of kw-hours in the first quantity block from the chart, follow the 1,500 kw demand line back to the line "A," then vertically down and read on the horizontal axis the approximate value 41,000 kwh. Reference to the bill shows that this block was listed at 63,400, (i. e. 63,200 + 200). As the second block is twice the size of the first, it also would be too large and the third block, which represents the remainder, would be too small. Since the two blocks which carry the higher unit rates were erroneously calculated too large, and the block which carries the low unit rate calculated too small, it is apparent that the source of the $800.00 error was in the calculation of the first quantity block. The statement should of course be returned, with attention directed to this fact.

The value of the chart as a check on power bills has now been established, but this is only one of the uses to which it may be applied. Its application to the analysis of power costs as affected by the selection of the proper equipment, and the load characteristics of the equipment when in service, is equally, if not more important and valuable, than for the purpose explained in this article. These considerations, however, will be treated in the third article of the series.

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*The term "load factor" is used in these articles in the sense as defined by the A. I. E. E., i. e., the ratio of average load to maximum load.

Heating Furnaces and Annealing Furnaces

Critical Comparison of Different Types of Furnaces, Continued. Continuous Furnaces—Test Results.

By W. TRINKS.

PART XXX.

COMPARED to the regenerative in-and-out furnace, the continuous or pusher type furnace offers many advantages. The stock is always charged at the same place, and is always delivered at the same place. The cost of materials handling is reduced, and the troubles arising from the use of regenerators are eliminated, etc.

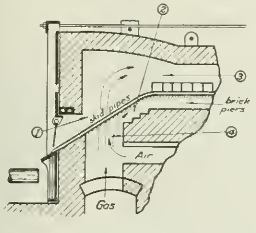

Fig. 227.

The continuous furnace is built in many modifications, notable among which are the differences arising from the method of discharge of the heated material. The latter may be taken out through a side door (side discharge), see Fig. 226, or else it can be pushed out through an end door (end discharge), see Fig. 170. Each of the two methods has its advantages and its disadvantages. The side discharge cannot be made automatic (it has, at least, not been done up to the present time), but requires a man who, by the aid of pinch rollers and of a bar, pushes out the billets one after another. The side door arrangement is particularly well adapted for use in continuous mills, starting with 1½-inch to 2½-inch square billets or with flats of similar cross section, because the rear end of the billet reaches the mill with the same temperature as the front end does. The first stand of the mill is located quite close to the furnace; it takes the billet at a slightly faster rate than the pinch rollers at the other end of the billet do. This feature is of decided value in the rolling of long lengths, with billets of 25 to 30 feet initial length, but it has the great disadvantage that it limits the furnace and mill capacity. It is manifestly impossible to feed a continuous mill from more than one furnace and still have the mill take the steel out of the furnace gradually. Consequently, the side discharge furnace and the continuous mill form one unit. As long as small sections are rolled by the mill, the time between billets is long enough for thorough heating and soaking; but if heavier sections are being rolled, the mill can handle steel much faster than the furnace can heat, unless the latter be made too large for average delivery. And that is practically never done, first, because floor space is as a rule too valuable; second, because there is danger of buckling of the small flats, and, third, because there is infiltration of cold air into a long furnace which is operated much below rated capacity.

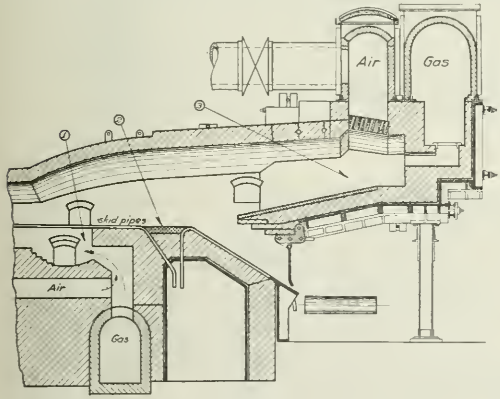

Fig. 228.

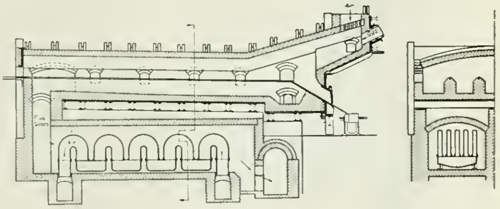

Fig. 229.

The limitation of mill capacity by furnace capacity is not a theory, but an actual condition. If the furnace is forced much beyond its rated capacity (70 to 75 pounds of steel per square foot and hour), the metallic recuperators either burn out or become leaky. They expand under the influence of high temperature and stick in the upper packing, when cooling again, lifting out of the bottom sockets. In cases of extreme overheating, the tubes buckle the metallic top and bottom division walls. In either case serious leakage results and the furnace "goes dead." The problem of constructing a furnace for 1½-inch to 2¼-inch billets, 24 to 30 feet long, for feeding a continuous mill, working with a wide range of products has not yet been satisfactorily solved, and the foremost builders of continuous mills advise to take the limitation of mill capacity by furnace capacity good naturedly, and let it go at that.

It may be added that small billets for being rolled in continuous mills are always heated on a solid hearth and not on water-cooled skids. The latter may

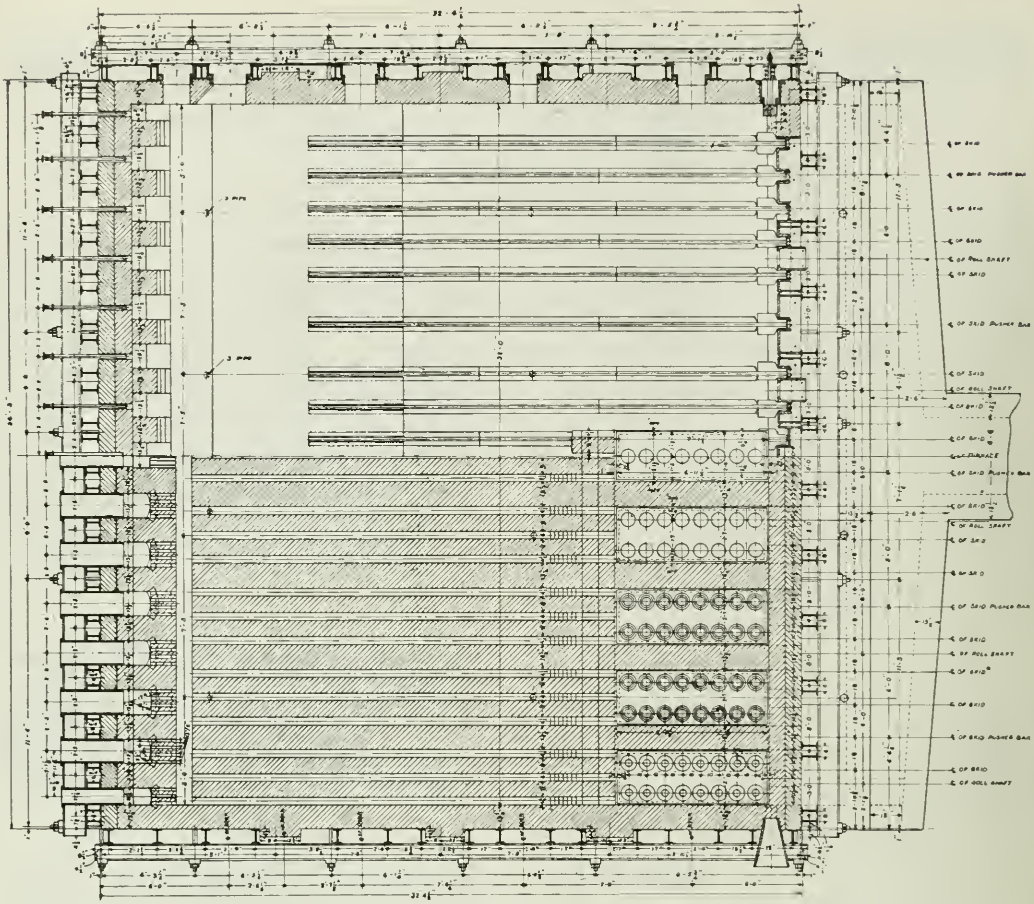

Fig. 226-A.

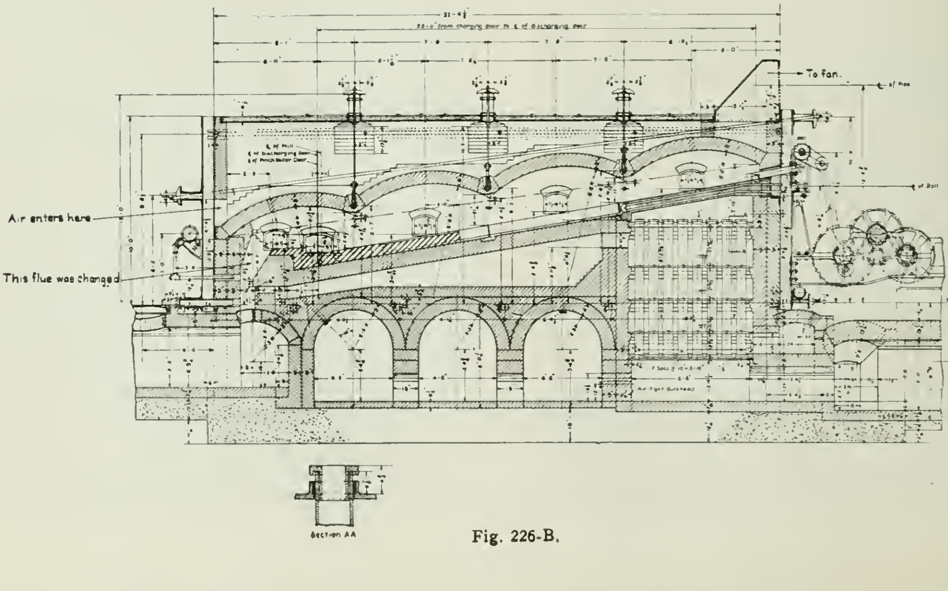

Fig. 226-B.

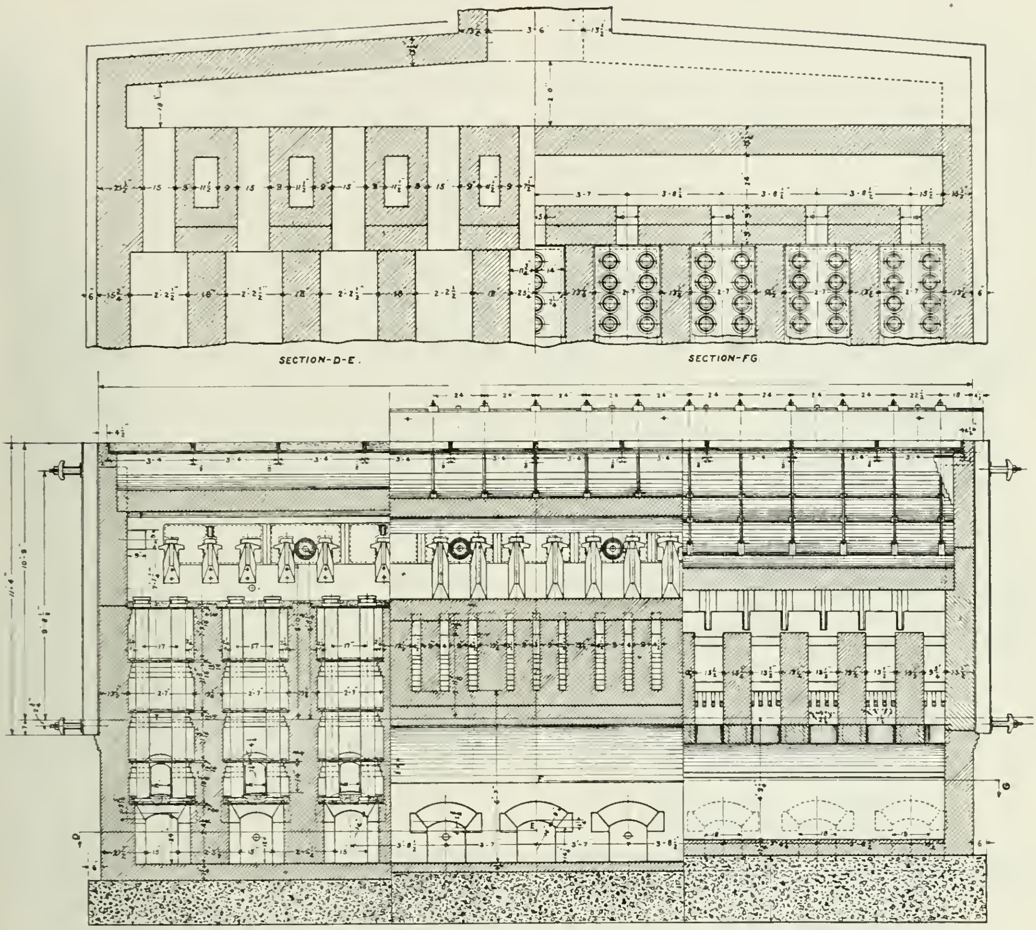

Fig. 226-C.

be used for some distance from the cold end, but must not extend very far into the hot end. Cold spots are quite objectionable in small billets and thin slabs, and are disastrous in continuous mills.

Continuous furnaces for larger billets, say from 3 to 3½-inch upwards, are almost invariably built with end discharge, or "gravity discharge." All patents on that method of discharge have expired and the design can be used by everybody. End discharge furnaces get around the before-mentioned limitation of the side discharge furnace, in as much as any number of furnaces can be arranged to feed a given mill, because the heated billets are discharged on a roller table. The nature of end discharge requires that the heated stock slide out of the furnace on skids; the latter must by necessity be water cooled, because they lie in the hottest part of the furnace. The requirements have frequently led to wrong design as diagramatically exemplified in Fig. 227 for producer gas. The design was shown for the latter fuel only, because a thorough understanding of the wrong features will permit avoiding smilar errors for any other fuel. Gas and air are mixed in a vertical duct (4) some distance below the heating chamber, for the purpose of making space (3) the hottest part of the furnace. The result is that a high temperature exists in space (1), back of the discharge door, and that an unduly large proportion of the combustion heat is radiated from that door, because the latter must be light so as to yield readily to the sliding billets. Not only do the discharge doors become red hot from radiation, but they frequently burn out from flames passing out through them.

In order to draw flame under the billets, openings (2) are left between the brick piers on which the skid pipes rest. Continuity between the space above and below the billets is secured by this arrangement, but cold spots are produced on the billets, because there is no forehearth. Finally, it is difficult to have complete combustion at (3), unless the mixing point of air and gas is placed very low. In that case the heat at (1) is extremely intense, and much heat is lost through the doors as well as into the skid pipes.

More recent designs of continuous furnaces avoid the drawbacks of Fig. 227. The tendency of modern designs is diagramatically sketched in Fig. 228. Fuel and air meet in a long, overhanging combustion chamber (3). The flame is thoroughly developed when it strikes the steel. At the same time, the discharge door is removed from the worst heat, lying at the end of a narrow slot, through which only a small amount of the heat can radiate. The pipe skids, instead of being continuous, are divided into two branches, one reaching from the cold end to the forehearth (2), and the other leading from the forehearth to the discharge. By this arrangement time is provided for the elimination of dark spots. Heating of the under side of the billets is accomplished by separate jets of flame (1), the temperature of which can be controlled apart from that of the flame sweeping over the top of the steel.

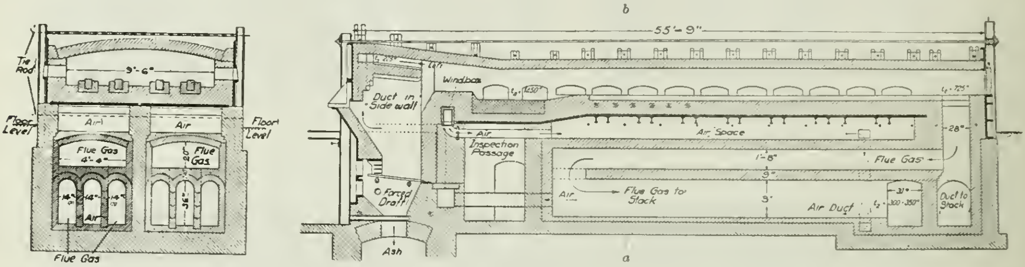

Fig. 230.

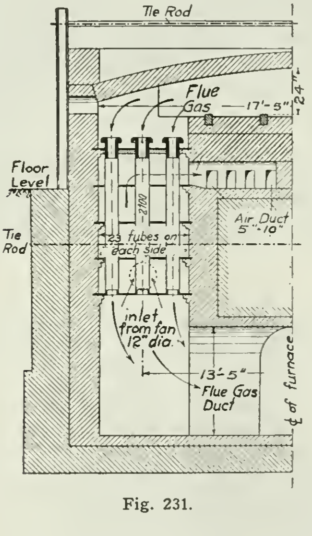

Fig. 231.

In the planning of a new continuous furnace, the question almost invariable arises: Shall it or shall it not be equipped with a recuperator? Saving of floor space and freedom from troubles caused by long furnaces call for a recuperator, or else for a short, uneconomical furnace, while freedom from recuperator trouble calls for the omission of a recuperator. In regions of cheap fuel the omission of the recuperators is favored for the sake of simpler operation and of reliability, particularly for natural gas or oil fuel. But the omission results in cold combustion air and in slower combustion.

In the United States the vertical recuperator of the Morgan furnace, Fig. 226, is very common and is very successful, if the furnace is not driven above its rated capacity. One advantage of the pipe recuperator is ease of renewals, particularly if the last arch of the furnace is arranged like a soaking pit cover, so that it can be lifted off in sections by the crane.

Another metallic recuperator which has found favor in the United States is the inverted U type, see Fig. 229. It is relatively free from expansion troubles up and down, but expansion in a longitudinal direction is restricted, and cracks occur. If cracks do occur, there is trouble ahead, because replacing a cracked section is almost equivalent to tearing the furnace down.

In Europe, particularly in Germany and France, tile recuperators are quite common. In Part VI the statement had been made that tile recuperators have, in general, been a failure in the U. S., because alternate slow and fast operation of the furnace cause the tile to crack or to open up in the joints. Even with the steady operation which the furnaces receive in Europe, the best grade of tile recuperator is guaranteed for only three years, as far as tightness is concerned.

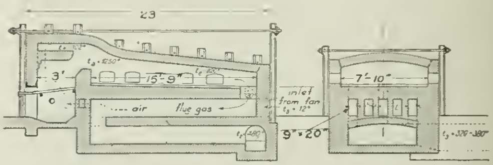

Fig. 232.

In conjunction with these facts, it will be of interest to study the drawings of some of these European furnaces, and to compare test data with those secured here. Figs. 230 to 232 were taken from "Feuerungstechnik," 1912, and show a number of European furnaces. Fig. 230 shows a continuous furnace for a rod mill. Billets are 4" x 4", 4 feet long; there are two pushers. The furnace is semi-gas fired; a steam jet forces air under the grate, while a motor-driven fan of 2,000 cubic feet per minute capacity against 6 inches of water blows secondary air through the wind box in the bridge wall, under the hearth, through the recuperator, through ducts in the side walls and through ducts between two arches into the fire. The heating surface of the recuperator is 440 square feet. It can be by-pased. The flue area is 8½ square feet. The stack is 130 feet high. Coal of 13,200 Btu. per pound and of 74 per cent carbon is burned on two grates of 22 square feet combined surface. Since 100 to 180 pounds of coal are burned per hour, 50 to 54 pounds (approximately) are gasified per square foot an hour. The following results were obtained: Cold charge in 10 hours, 219,000 pounds. Loss by oxidation 3½ per cent. Coal consumption in 10 hours, 12,500 pounds, or 5.7 per cent of the charge. Temperatures: Of billets, 1930 to 2100 degrees F. At hot end of hearth, 2650 degrees F.; at cold end of hearth, 1290 degrees F. to 1380 degrees F., of the flue gases beyond recuperator, 570 to 670 degrees F.; of air in delivery nozzle, 440 degrees F. The overall thermal efficiency of the furnace is 42 per cent. The ash contains from 8 to 12 per cent carbon, and the flue gas contains 10 to 12 per cent CO_2. The heat transmission coefficient through the recuperator walls is 0.37 to 0.48 Btu. per square foot per degree F. an hour. The rate of heating is only 60 pounds per square foot of hearth an hour.

Many Morgan furnaces with metallic recuperators are in use in Europe. When fired with producer gas they show a thermal efficiency of about 45 per cent. This value is lower than what we are used to with natural gas or with coke-oven gas, but is very good in view of the producer losses. Morgan type furnaces for short billets have been equipped with laterally arranged recuperators, see Fig. 231. A furnace of that type in a German rod mill, with a hearth area of 815 square feet showed the following results: Coal consumption, 5.8 per cent of output when operated at the low rate of 41 pounds of steel per square foot of hearth an hour. (The furnace had been built for large output.)

Fig. 232 shows a simple recuperative continuous furnace serving a projectile press. The method of firing is the semi-gas principle. Hearth area 118 square feet; grate surface, 14 square feet. Steam jet blower for primary air; fan for secondary air. Parallel flow recuperator under hearth, 123 square feet heating surface; 6¼-inch walls. Coal, 13,000 Btu. per pound with 73 per cent C. Ash contains 20 to 25 per cent C. Cold charge 1940 pounds of billets per hour. Oxidation loss 3.1 per cent. Coal used 292 pounds per hour = 15 per cent of charge. The rate of combustion equals 24.6 pounds per square foot an hour. The hearth area is rather large for the work. Temperatures: At bridge wall, 2300 degrees F.; beyond hearth, 1500 degrees F.; at entrance to recuperator, 1330 degrees F.; beyond recuperator, 900 degrees F.; in the flue, 610 to 700 degrees F. CO_2 in the flue gas, 5 to 8 per cent. Temperature of preheated air, 215 degrees F., for a room temperature of 55 degrees F. Thermal efficiency, 16 per cent.

It may be of interest to have operating data on the furnace shown in Fig. 226. Tests showed the following results: Capacity, 170 billets per hour of 2" x 2" x 30' size; final steel temperature, 2200 degrees F. Gas consumption, 1,385 cubic feet of natural gas per long ton of steel. Apparent temperature at bridge wall, 2600 degrees F., with air preheated to 450 degrees F. Temperature at end of hearth, 1500 degrees F.; at entrance to recuperator, 1125 degrees F. Stack temperature, 820 degrees F. Air was preheated from 80 degrees entering temperature to 180 degrees F, leaving temperature by passing over roof. A large portion of the air (approximately 25 per cent) of the air leaked out of the brick ducts under the hearth. In more recent furnaces, these brick ducts are lined with cast iron, in order to minimize the leakage.

Electric Furnaces for Making Steel

General Features and Advantages of the Ludlum Furnace and of the Vom Baur Furnace—Classification of Electric Steel-Making Furnaces.

By ALFRED STANSFIELD, DSc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART IV.

THE Ludlum furnace belongs to the series-arc class. It resembles the Heroult furnace in a general way, but differs from it in being oval instead of circular, in plan, and in having the three electrodes arranged in a straight line instead of a circle. The furnace is supported on two sets of rollers and tilts endwise to pour; it has a door at each end, one of which serves for a spout, and the electrode supports are at one side of the furnace. The general design of the furnace is shown in figures 17 and 18.

The simplest electric furnace for melting metals has one movable electrode and a bottom-contact, and is circular in plan; it has the smallest wall-area for a given volume and, therefore, the heat-losses and the furnace upkeep should be a minimum. The majority of modern furnaces have three electrodes, and the question arises whether these should be arranged in a triangle within a circular furnace, or in a straight line in a rectangular or oval furnace; the Heroult furnace is constructed on the former plan while the Ludlum and some other furnaces are oval, with the electrodes in a straight line. The wall of a circular furnace cannot be equally heated at every point by a group of three electrodes arranged in a triangle, while an oval furnace can be designed so that the entire wall shall be heated equally by three electrodes arranged in a straight line. The oval furnace has a somewhat longer wall than the circular furnace, for the same volume of contents, but the wall is more evenly heated by the radiation from the arcs. The

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oval furnace tilts endwise to pour, and has the advantage that it need not be tilted through so large an angle as would be necessary if it were circular.

The roof of the Ludlum furnace is a flat arch of fire-clay brick held in a simple steel frame and arched from side to side. The makers state that it will last for several weeks of continuous operation and when worn out it can be replaced by a new one which is kept in readiness, without much delay. The change is conveniently made when the furnace has been freshly charged with steel-scrap, and in this way very little heat is lost and scarcely any delay is caused.

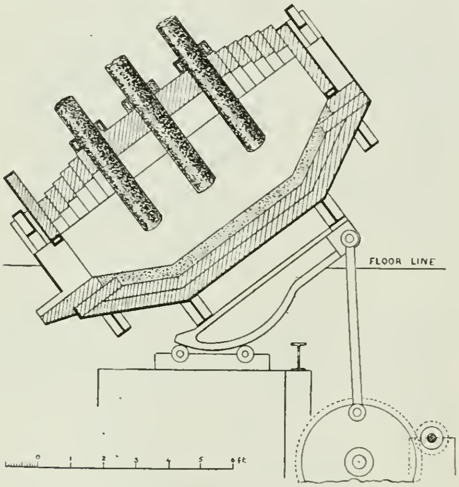


Fig. 17—Three-ton Ludlum furnace—tilted.

The hearth of the furnace is circular in cross-section, as is shown in Fig. 18, and extends up to the roof so that there are no straight sidewalls; this lessens the danger of any bricks becoming loose and falling out when the furnace is tilted. For basic operation the hearth has nine inches or more of magnesite brick with a working lining of crushed magnesite; the setting of this lining can be done easily, as a single piece of old electrode laid on the hearth will serve to start the three arcs for heating the empty furnace. It will be noticed that the electrodes are all placed over the deepest part of the furnace, and in melting steel-scrap there is, therefore, no danger of an electrode melting its way through the charge and into the furnace lining. In starting the furnace the electrodes rest on the charge and before they have melted their way through there will be a pool of melted metal beneath them which protects the hearth. The arcs are then surrounded by the charge, so that little heat is lost until the steel is all melted. The construction of the Ludlum furnace can be seen clearly in the photographic views reproduced in Fig. 19, which shows the electrodes, the water-cooling supply and the charging door, and in Fig. 20, which shows the pouring spout and the electrode supports and motors.

Graphite electrodes are used, which do not weaken the roof so much as carbon electrodes of the same capacity. A three-ton furnace uses six-inch graphite electrodes and is furnished with transformer capacity of about 750 kva. A six-ton furnace uses nine-inch electrodes and 1,500 kva transformer capacity, while a ten-ton furnace uses twelve-inch graphite electrodes and needs about 2,250 kva of transformer capacity.

The furnaces operate at the usual voltages—about 90 for full load; the average power-factor is said to be at least 90 per cent, and it is claimed that the transformer and automatic electrode regulation causes the furnace to operate smoothly and without large surges of power. The transformer connections may be star-star, star-delta or delta-delta.

The Ludlum Electric Furnace Corporation have more than twenty furnaces in operation; of these four 10-ton, four 6-ton, three 5-ton, one 3-ton and one 2-ton standard furnaces are making alloy steels or castings, while ten special furnaces are used for other work.

In addition to steel-melting, Ludlum furnaces have been used for the duplexing of grey iron, that is the use of an electric furnace in combination with a foundry cupola for the production of iron castings. The cupola is a very efficient and economical melter, but it has the disadvantage that the iron absorbs sulphur from the fuel. The amount taken up in a single melting is not very great, but as each charge contains a proportion of scrap and as some of the iron must, therefore, be melted repeatedly, the amount of sulphur in the scrap is constantly increasing. In the duplex process, the iron is melted in the cupola, using just enough coke for the purpose, and the melted iron is then transferred to an electric furnace, where it is superheated, desulphurized and freed from oxides, slags and dissolved gases. The electric treatment is not costly and produces castings of superior quality.

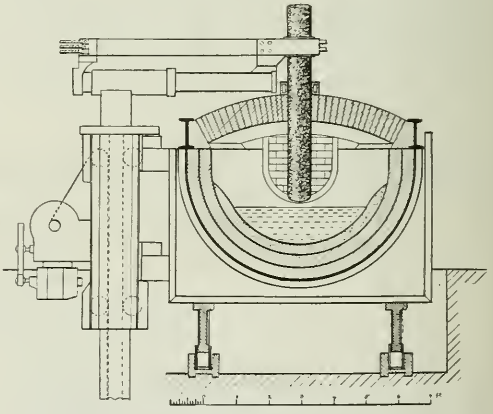


Fig. 18—Three-ton Ludlum furnace—cross section.

At the American Cast Iron Pipe Company, Birmingham, Ala., agricultural scrap with a small amount of pig iron is melted in two large cupolas, each of which will furnish about 3½ tons in fifteen minutes. The combined product of seven tons is poured into a six-ton acid-lined electric furnace and superheated for fifteen minutes, during which time the necessary additions of ferro-silicon, etc., are made. The energy used is about 65 kw hours per ton and about one pound of nine-inch graphite electrode is used per ton of iron. The power supplied must be nearly 2,000 kw during the operation. As the cupolas are melting one lot of metal while the electric furnace is treating the previous charge, the complete cycle of operations only takes about 20 minutes, and more than 400 tons of metal are treated in 24 hours. The iron is made very hot, as it is used for casting 16-foot lengths of four-inch iron pipe of the thinnest sections, but the temperature is much less than is regularly needed for steel-making, and the roof lasts almost indefinitely.

At the foundry of McCord & Co., Chicago, a basic-lined Ludlum furnace is in use for treating iron for automobile cylinders. Only three tons are treated at a time and as the metal is desulphurized under a limey slag, as well as being superheated, the time of treatment is longer, about 35 minutes; the energy consumed is from 125 to 140 kw hours per ton, and about two pounds of electrodes are used per ton of metal.

The duplexing of grey iron is described by G. K. Elliott in vol. 28 of "The American Foundryman's Association," and in vol. 35 of "Transactions of the American Electrochemcial Society."

Apart from duplexing, the electric furnace has been used for melting cast-iron borings, and has the advantage of treating material of this kind with very little loss. In November, 1920, a test was made in the foundry of the Ludlum Steel Company at Watervliet, N. Y. The borings were melted in two heats of 2¼ tons in a three-ton basic lined Ludlum furnace; additions of coke, lime, carbide slag and ferro-silicon being made as required. The length of each heat was about 3½ hours and the power used about 400 kw. The average energy for the two heats was 574 kw hours per ton and the melting loss was 2.75 per cent.

The writer is indebted to Mr. John Kelley, of the Ludlum Electric Furnace Corporation for information about the construction and operation of the Ludlum furnace and for Figs. 19 and 20.

Vom Baur Furnace.

The Vom Baur furnace belongs to the series-arc class and closely resembles the Ludlum furnace. It has been in use for about six years, and is made in various sizes up to 10 tons capacity. Like the Ludlum furnace it is oval in plan, and has the electrodes arranged in a straight line. The Vom Baur furnace is shown in outline in Fig. 21. It is mounted on rockers and tilts endwise to pour.

It is claimed for this furnace that the straight line arrangement of the electrodes allows the walls to be equally heated at every point by radiation from the arcs, and that this is not the case in the circular three-electrode furnace. This point in furnace design, which applies equally to the Ludlum furnace, may be discussed briefly, on the assumption that the heat reaching any part of the furnace wall, from each of the arcs, is proportional to the heat produced in that arc and inversely proportional to the square of the distance.

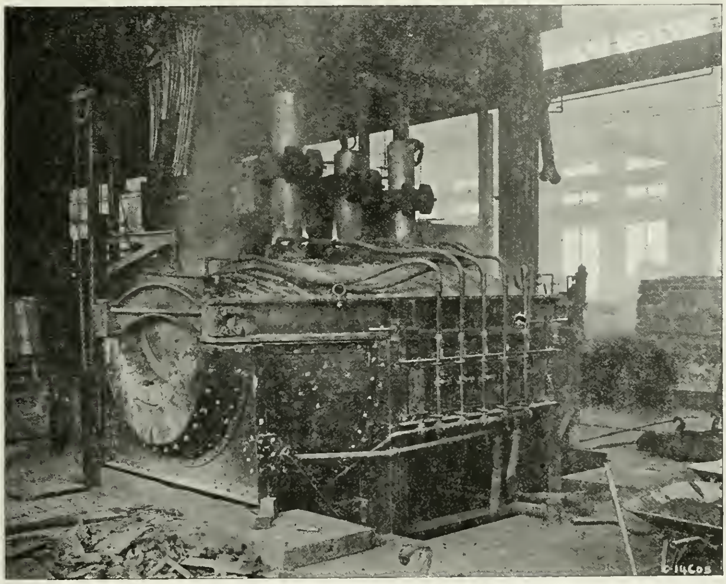


Fig. 19—Six-ton Ludlum furnace—charging end.

Fig. 22—Ideal Outlines of Three-Electrode Furnaces.

In Fig. 22, the circle D G E represents a circular furnace of eight-foot internal diameter, and A, B and C are 17-inch electrodes arranged in a circle of 21 inches radius, these dimensions corresponding to the six-ton Heroult furnace shown in Fig. 14. If the three arcs are equal, the heat reaching any point should be proportional to the sum of the inverse squares of its distances from the three electrodes, and for simplicity we may measure from the center of each. When this is done we find that the heat reaching E is about two-thirds of the heat reaching D, and in order that the wall shall be heated equally at each point it should be of a three-lobed form HIF as shown, in which the radius OF is about eight inches less than O D. The effect of this want of uniformity in the heating of a circular furnace will be that the three points G E and J will not be sufficiently heated, or on the other hand, if there is sufficient heat at these points, the parts D K and L of the wall will be overheated.

The oval D E G represents a furnace of 104 inches by 70 inches, drawn to the same scale and having three 14-inch electrodes spaced 24 inches between centers, these dimensions corresponding with the six-ton Vom Baur furnace of Fig. 21. Assuming equal sources of heat at A, B and C, it will be found that the points E and G will be equally heated. The wall of the Vom Baur furnace is curved where it crosses the major and minor axes, but has a straight section in between these curves, as is shown in Fig. 21. Repeating the calculation, however, for a point F, between E and G, it will be found that the wall should be an oval as shown in this figure with no straight sections. The curve shown in the figure is practically an ellipse having its foci at points midway between D and A, and C and G.

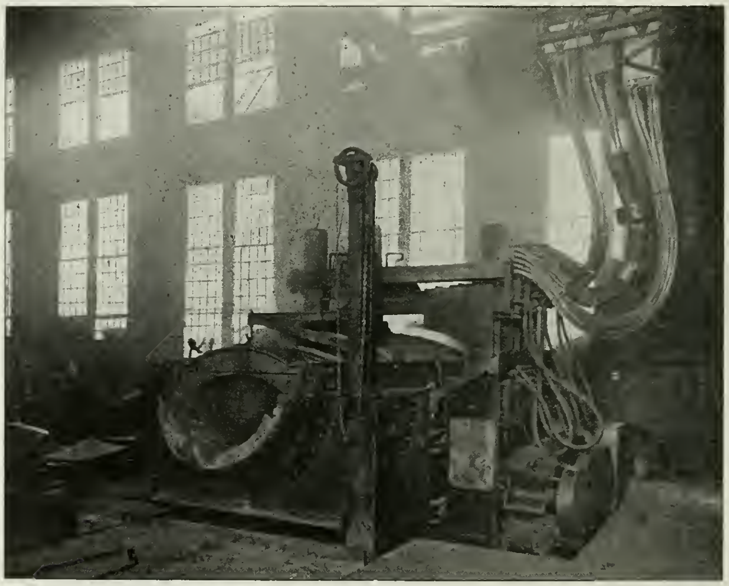


Fig. 20—Six-ton Ludlum furnace—pouring end.

The Vom Baur furnace is supplied with two-phase current, the middle electrode forming the common return and carrying, perhaps, 30 per cent more current than either of the end electrodes. The normal condition for a two-phase current is for the central electrode to make contact with the molten steel, so that arcs are only formed under the end electrodes; the current passing through the middle electrode will then be 1.41 times that in each end electrode. If the middle electrode is raised, so as to start an arc, the current through this electrode becomes less, and in practice it cannot be more than 1.3 times the current in the other electrodes. As this electrode is raised higher the current in it will decrease further and finally will become zero, while the end arcs will continue to operate. The heating effect of the central arc may be taken as the product of the current and the voltage of this arc, and this product is in all cases decidedly less than that for either of the end arcs. The two-phase supply is probably a satisfactory arrangement, but it does not furnish a large part of the power to the central electrode. The lack of heat-production in the middle of the furnace will be offset by the loss of heat from the doors, which are situated at the ends of the furnace, and in view of this the oval shape of the furnace may be quite satisfactory.

Mr. Vom Baur informs me that with a two-phase supply, obtained from Scott-connected transformers, he found currents of 5,000 amperes in each end electrode and 6,400 amperes in the middle electrode, when all three electrodes were arcing well (the voltage of each arc was not measured, however), and that, with a modified Scott connection using three transformers, he has obtained as much as 50 per cent more electrical heat under the middle electrode than at either of the end electrodes.

It seems evident from Fig. 22 that a three-phase supply would serve satisfactorily to heat an oval furnace, but two-phase current offers certain advantages, thus, in melting a cold charge the central electrode can be let down on to the scrap metal and the arcs maintained at the ends only, without unbalancing the load, as would occur if this were done with a three-phase supply. To regulate the electrodes, when using a two-phase supply, the end electrodes can be controlled by the ammeter readings, but the middle electrode must be regulated by the voltage between it and the hearth of the furnace.

The design of the Vom Baur furnace seems to be satisfactory, and the furnace strongly constructed. The endwise method of tilting enables the steel to be poured from the furnace with a smaller degree of tilt than usual, being 7 degrees in one direction, to remove the slag, and 31 degrees in the other direction, to pour the steel. Tilting is effected by an electric motor driving large spur wheels, which are connected by rods to the rocking frame of the furnace, so that if they continue to revolve in one direction the furnace will rock back and forth through its limited range of motion.

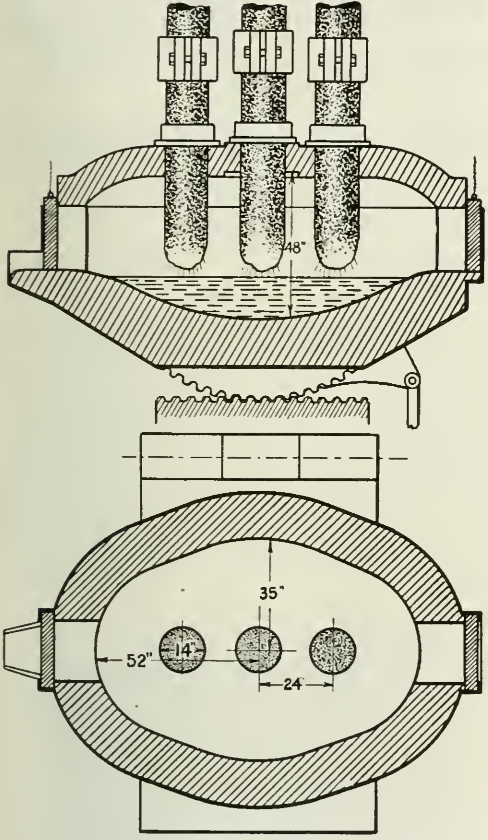


Fig. 21—Six-ton Von Baur furnace.

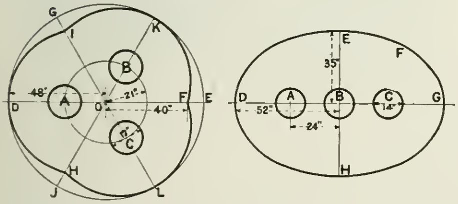


Fig. 22—Ideal outlines of three-electrode furnace.

The power supplied to the Vom Buar furnaces is shown in the following table:

Capacity	Power per ton	Transformer power
½ ton	500 kw	250 kw
1½ ton	400 kw	600 kw
3 ton	400 kw	1,200 kw
6 ton	250 kw	1,500 kw

Furnaces of 10 tons and larger are also built. The general dimensions of a six-ton furnace are shown in Fig. 21. The furnace is 104 inches by 70 inches inside and about four feet high. The three electrodes are each about 14 inches in diameter and they are 24 inches apart, center to center. The walls are 14 inches thick, the bottom 16 inches and the roof 9 inches thick. The roof is strongly arched from back to front and has also a slight arch from end to end.

The following furnaces had been sold by August, 1919:

In United States	one 6-ton	1,800 kw
In United States	one 3-ton	600 kw
In Japan	two 6-ton	1,500 kw and 1,250 kw
In Japan	one 1-ton	500 kw
In France	one 6-ton	1,500 kw

References to Vom Baur and Ludlum Furnaces.

C. H. Vom Baur, "The Vom Baur Arc Furnace," Trans. Amer. Electrochem. Soc. 1918, vol. 33, p. 237.

C. H. Vom Baur, "Vom Baur Arc Furnace," Chemical and Metallurgical Engineering, 1919, vol. 20, p. 488.

C. H. Vom Baur, Park Row Building, New York.

HENRY C. WALLACE IDENTIFIED WITH IRON AND STEEL BUSINESS.

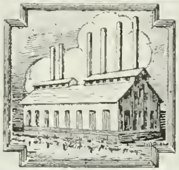
An incident is related of Henry C. Wallace, the new Secretary of Agriculture, which identifies him with the iron and steel business in an interesting way.

Several years ago the readers of the farm publication of which he is editor made complaint of rapidly rusting fence wire. Henry C. Wallace put their problem up to the Agriculture Department, the same as he would have done in case an inquiry had come regarding a mysterious disease among livestock. Instead of a sick hog, it was a case of sick steel.

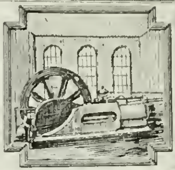
The readers wanted to know why the wire fences they put up did not last like the old-fashioned wire fences their fathers had put up before them. Rust seemed to be playing havoc. The government metallurgists at Washington asked for specimens of old fence wire which has resisted corrosion, along with samples of the new fence wire which had rusted so rapidly, for the purpose of comparison and analysis. Young Wallace spent one whole week gathering the samples of old iron wire fences, some that had stood so long that the wooden cross bars had rotted away.

The specimens which he sent on to the Department of Agriculture at Washington were analyzed by the department metallurgist, and a bulletin was issued calling attention to the fact that modern rapid practice in stel making had left the metal full of impurities, as compared with the old-fashioned hand-made iron, and that the presence of these impurities caused the rapid corrosion of the new fence wire.

As a result of this little bulletin issued by the Agriculture Department, the manufacture of pure iron on a commercial scale was sucessfully undertaken, and the product not only applied to wire fences, but also to the different forms of sheet metal, where rust resisting iron is an essenial economy.



STEAM POWER DEPARTMENT



Improving Modern Boiler Room Practice

The Use of Cheaper Coal, Elimination of Smoke and Reduction In Labor Through Better Methods of Combustion—Advantages of Mechanical Stokers.

By **ROBERT JUNE, Mechanical Engineer.**

POWER is one of the largest items of expense in most manufacturing businesses, and the cost of fuel represents on the average 70 per cent of the cost of power. And the cost of fuel is going up. Nothing short of the discovery of a new source of power can stop the rising tendency of coal prices.

Since waste in the coal pile represents dollars which should be conserved for the dividend pile, it stands the power plant operator in hand to use the most economical grade of fuel.

The first point to bear in mind is that the most economical grade of fuel varies with different furnaces and methods of combustion. As an illustration: Coal selling at a very low price per ton may be more expensive to burn than a better grade of coal under certain furnace conditions. When these conditions are changed, it may be found that a cheaper grade of fuel is the most economical and that an appreciable saving in operating costs has been effected through the improvement in methods of firing.

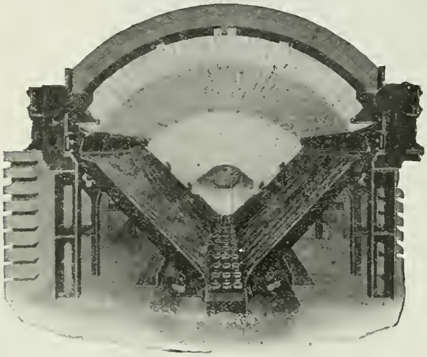


Fig. 1—Rear end view, Detroit V-type stoker, radially sprung arch.

The furnace is often the weakest link in the chain of economical steam production. The amount of coal burned to produce the results demanded is often far in excess of what would be required by careful, intelligent management. In many cases, existing plants have been redesigned for a cheaper grade of fuel, and it is today becoming quite frequent practice to design boiler furnaces especially to permit the use of a low grade of fuel.

One of the conditions necessary to the efficient, and in particular, the smokeless combustion of coal, is uniform liberation of the volatile gases. This is a condition which practically never can be realized in the hand-fired furnace. Inasmuch as the hand-fired furnace also presents pretty definite limitations in the way of utilizing the cheapest grades of fuel, we find that the way to improve boiler room operating conditions is to install mechanical stokers.

Advantages of Mechanical Stokers.

Among the advantages attaching to the use of mechanical stokers are the following:

a. Hand firing is intermittent and its evenness and effectiveness depends on the individual skill of the fireman and the degree of attention which he accords his work. With the automatic stoker, firing is continuous and uniformly even.

b. Cleaning of fires in hand-fired furnaces is also intermittent, often erratic, and is dependent upon the skill of the fireman. With stokers the fires are automatically and continuously cleaned, thus insuring increased efficiency in combustion.

c. With hand firing there is a constant opening of doors, thus admitting large quantities of cold air into the furnace. The depth of the fuel bed is also a variable factor and the amount of air that comes up through the fuel bed accordingly varies from one time to another. With stokers, on the other hand, it is possible to secure a practically constant and uniform supply of air, which can be controlled to agree with operating conditions.

d. With hand firing, one fireman can at the best take care of from 250 hp to 500 hp of boilers, whereas with automatic stokers one fireman can take care of 2,000 to 3,000 hp of boilers, hence, the stokers reduce the item of labor cost 75 per cent or more.

e. One of the outstanding advantages of automatic stokers is their ability to burn efficiently cheaper grades of fuel than can be burned to advantage with hand firing. The importance of this factor can readily be estimated as a saving in this direction alone that may amount to enough to pay for the stoker installation several times over in the course of a year.

f. With hand firing, it is next to impossible to prevent the discharge of large amounts of smoke from the stack. This is due to the intermittent character of the firing and the lack of uniformity in the liberation of the volatile gases. With the stoker, the smoke nuisance is to an appreciable extent within control.

The Case of a Steel Plant.

The writer's attention has recently been called to two steel plants of approximately equal capacity. One of these plants has hand-fired furnaces, and, further, the bad conditions of this type of firing had a psychological effect on those working in the boiler room. The place was in a generally ill-kept and unsatisfactory condition. The other plant was equipped with mechanical stokers, and, perhaps, because the attainment of efficiency in combustion stimulated the firemen to better work all around, the boiler room was in first-class condition. The first plant was using half again as much coal as the second, and because of the very bad features of boiler room operation, the cost of steam generation was actually twice the cost of generation in the second plant.

A study of the psychology of the fireman who labors under adverse conditions is replete with interest. Too often he works in a dimly lighted boiler room with equipment so inefficient that any incentive he may have toward improving conditions becomes buried. Where careless management prevails, coal soon comes to mean nothing to him but a black substance of unlimited supply. When the storage space gets empty, coal cars or motor trucks refill it. The boss who pays for it makes no demands regarding the saving of fuel. The management's one demand is that steam should be kept up, and, therefore, why should he, the fireman who shovels coal hour after hour and day and after day, be concerned with anything but the pressure gauge?

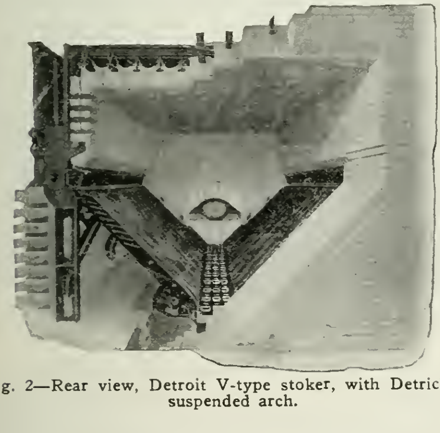


Fig. 2—Rear view, Detroit V-type stoker, with Detrick flat suspended arch.

This was the condition existing in the first boiler room. When the management finally took up the problem of reducing the cost of steam generation, they found the firemen ready and willing to coöperate. When it was proposed to install stokers the management found the men actually welcoming the idea, although they realized that some changes would have to be made in the number of men working in the boiler room. For this particular plant a general type of mechanical stoker was chosen. After the installation had been completed, it was found that a cheaper grade of fuel than had previously been used could be burned, and that, due to the uniformity with which the stoker fed the fuel, the proper proportion of air for combustion, the absence of large amounts of excess air, the self-cleaning feature of the grates, etc., that it was possible to maintain a uniform boiler efficiency of approximately 70 per cent, whereas 55 per cent had been the rule before, and that the same amount of steam could be generated with considerably less coal.

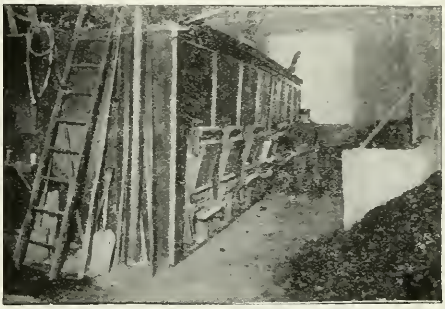


Fig. 3—Before installing stokers, boiler room dirty and ill-kept, efficiency low, costs high.

With the installation of the stokers, a transformation took place in the boiler room. The firemen began to display a hearty interest in their work, with the result that espirit de corps of the operators and the whole appearance of the boiler room was changed. As a result, the cost of producing steam in the plant was reduced something like 50 per cent. bringing it down to the cost in the second plant. There has been no difficulty in maintaining costs at this low figure.

Standardized Firing Practice.

Daily records are essential with any method of firing, if economy is an object. These reduce to the low-limit the human element. From them is derived the proper adjustment of air supply, rate of feed, and depth of fire. It should be the aim of the operating engineer to standardize his firing practice.

When a condition of smokelessness of stacks is desirable by reason of local smoke-regulating ordinances, or because of its injury to the manufactured product (as in paper mills), the best results can be obtained by the use of mechanical stokers. The reason for this is that, as compared with hand firing, there is a much longer time for combustion. As the volatile gases are distilled, they are acted upon by ignition arches prior to coming in contact with the cooler heating surfaces. Otherwise they would fail of ignition, and pass out the stack unconsumed. Where space permits, stokers may be installed so that they extend beyond the boiler front. This gives an added length of travel, during which the gases are acted upon by the radiant heat from the ignition or supplementary arches, and are properly consumed.

Stokers, as has been stated, often reduce labor costs 50 to 75 per cent, or more. The slow-running, self-cleaning types require much less attention than hand-fired furnaces.

A general description of the Detroit stokers used in this plant may be interesting. Two magazines, located on each side of the stoker, supply the coal. Coking plates are inclined at a steep slope toward the center of the furnace. As the coal leaves the magazines, it rests for a short period on the coking plates. During this time the volatile gases are driven off and mixed with air which has been pre-heated by admission through the arch over the fire.

Gravity plays an important part in the operation of this type, and little power is required to actuate clinker crusher and oscillate the grates. The fuel travels slowly down the inclined grates toward the clinker grinder, receiving the requisite amount of air through the grates to complete the process of combustion. By the time the lower portion of the grate is reached, the combustion is completed, and ash and clinker are removed automatically. Maintenance cost is low, due to the small number of parts coming in contact with the fire.

Stoker boxes push the coal into the grates. The speed of this operation is easily regulated. As combustion proceeds, the grates oscillate and have a slicing effect on the fuel. This permits free admission of the air and assures complete combustion. In stokers of this type, the clinker grinders can be adjusted to operate independently of the remainder of the mechanism. If the coal contains a large amount of ash and clinker, the grinder may be adjusted to operate faster, to remove them. At the same time, the coal may be fed at a slow rate if desired.

Results of Stoker Tests.

The savings in coal effected by the use of mechanical stokers are very large. This result is to be expected in view of the fact that stokers increase the overall boiler efficiency from the general average of 55 per cent for hand-fired boilers to a general average of 70 per cent for stoker-fired. As indicative of the high boiler efficiency readily obtained from the use of mechanical stokers, we include Table 1, which shows results of a test at normal rating on Detroit stokers at a well-known steel plant.

Table 1.

Test on one Detroit V-type stoker, manufactured by Detroit Stoker Company, Detroit, Mich., on one H. R. T. boiler, 66" x 18' 0" (Vogt).

	Horsepower of boiler (owner's rating)	120 H. P.
	Size of stoker	4' 11" x 5' 3"
	Grate surface	27 sq. ft. projected
	Kind of fuel	Kenawa gas coal slack
	Duration of trial	8 hours
TOTAL QUANTITIES—		
1	Duration of trial	8 hours
2	Weight of coal as fired	3576 lbs.
3	Per cent of moisture in coal	5.38%
4	Total weight of dry coal fired	3384 lbs.
5	Total ash and refuse	463 lbs.
6	Per cent of ash and refuse in dry coal	13.7%
7	Total weight of water fed to boiler	32,508 lbs
8	Factor of evaporation	1.083
9	Equivalent of water fed to boiler from and at 212 degress	35,206 lbs.
HOURLY QUANTITIES—		
10	Dry coal fired per hour	423 lbs.
11	Dry coal per sq. ft. of grate per hr.	15.66 lbs.
12	Water evaporated per hour	4,063.5 lbs.
13	Equivalent water per hour from and at 212 degrees	4,400.7 lbs.
AVERAGES AND TEMPERATURES—		
14	Steam pressure by gauge	99.6 lbs.
15	Temperature of feed water	170.3 deg. F.
16	Temperature of flue gas	507 deg. F.
17	Force of draft in breeching	
18	Force of draft over fire	.10"
HORSEPOWER—		
19	Horse power developed	127.5
20	Builders' rated horsepower	120
*21	Per cent of builders' rating developed	106.3%
ECONOMIC RESULTS—		
22	Water evaporated per pound of coal as fired	9.09 lbs.
23	Equivalent evaporation from and at 212 degrees per pound of coal as fired	9.84 lbs.
24	Equivalent evaporation from and at 212 degrees per pound of dry coal	10.40 lbs.
25	Equivalent evaporation from and at 212 degrees per pound of combustible	12.05 lbs.
COAL ANALYSIS—		
	Moisture	5.38%
	Volatile carbon	
	Fixed carbon	
	Ash	10.0%
	Btu. of coal as fired	13,088
	Btu. per pound of dry coal	13,833
EFFICIENCY—		
	Efficiency of boiler, including stoker, based on dry coal	72.6%

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*NOTE—Test purposely run at normal rating of boiler.

Details to Be Remembered in Handling Stokers.

After your stoker has been installed, the first thing to do is to determine standard practice for firing. A little experimental work done by one of your competent engineers will enable you to lay down the rules to be followed in handling your stokers. After the standard practice has been formulated, it should be typewritten and placed at one or more points in the boiler room and the work of the fireman should be checked regularly. Remember that rules are of value only if they are followed.

Be sure that the following points are embodied in your rules for stoker operation:

a. Keep draft under close control at all times. It is very desirable to use draft gauges with all types of stokers.

b. See that your air vents are kept open, so that there will be no obstruction to the passage of the air.

c. Do not allow air leaks which may develop in the furnace to remain unattended to.

d. See that the ash pit is cleaned out regularly at frequent intervals. Check up the CO_2 in your flue gas regularly. If the percentage falls below standard, find out why.

e. Remember that coking coal may require the use of a slice bar.

f. Do not under any circumstances get water upon the arches or brick work when you are washing out the boiler.

g. Do not stop the stoker engine when hopper is full of coal. If an emergency stop is necessary, clean out the hopper.

h. Attend to all maintenance work promptly and your repair bills will be small.

In conclusion, if you wish a high standard in boiler room practice, equip your boilers with the necessary apparatus and assure yourself that your operatives are sufficiently familiar with the equipment in the plant to handle it intelligently under varying conditions of load.

Cambria Steel Company New Boiler Plant

A General Description and List of Equipment Installed in the New Boiler Plant of the Cambria Steel Company at Johnstown, Pa.—One of the Most Modern Boiler Plants in the Steel Industry.

By E. W. TREXLER, Steam Engineer,
Cambria Steel Company, Johnstown, Pa.

IN December, 1920, the Cambria Steel Company put into operation a new boiler plant at their Johnstown works. It was necessary to make this addition to their plant because of insufficient steam generating capacity. In the construction of this new plant, only modern equipment was considered and since its operation it has in every way successfully met the expectations of the Company's engineering staff. Although this plant has been in operation during the past seven months and although no efficiency tests have been run, everything points to an economical operation with an exceptional good heat balance for the entire plant.

Due to the prominent location of the building, which is located opposite the Pennsylvania Railroad Depot on the main line of that railroad at Johnstown, it was necessary to give the building a pleasing appearance. The building is constructed of steel, concrete and brick and is fully equipped with large windows. This not only adds to the appearance of the building but makes the interior of the plant exceptionally well lighted. A wash room and shower bath have been installed in the building and a large room on the ground floor for the storage of spare parts has been provided.

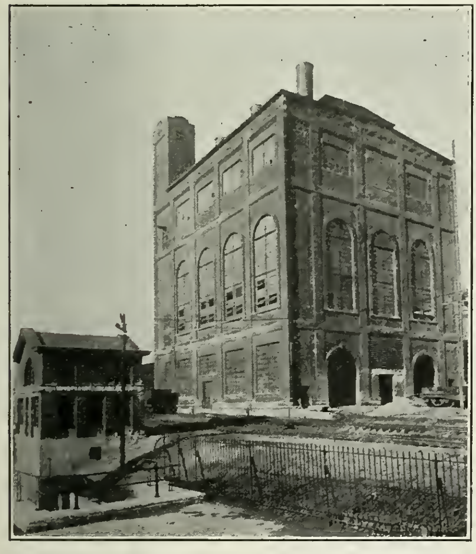


Fig. 1—General view of exterior of plant.

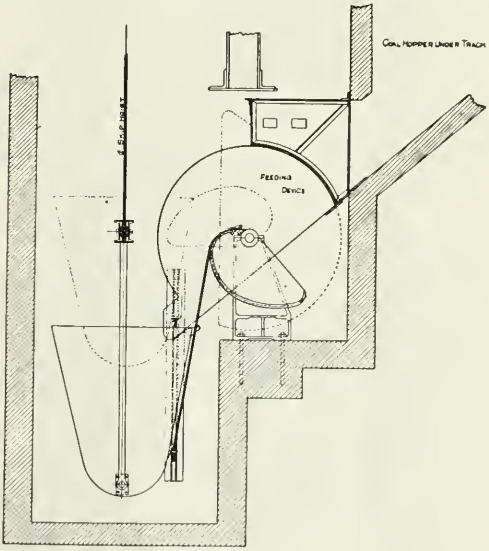


Fig. 2—Coal handling device.

The coal conveyors and coal bin are completely enclosed by brick walls so as to be entirely separated from the rest of the building. This prevents coal dust from this source being scattered throughout the remaining portion of the building.

As shown in Fig. 3, the forced draft fans and feed pump are located under the central part of the boiler room floor. There are stairways at each end reaching up to the main floor. A large opening equipped with louvres at one end of the forced draft fan room was intended as a source of air supply to the fans. However, it was found necessary in order to distribute the air equally among the six fans, to open up holes in the floor at equally distant points throughout its length. The first mentioned opening was then closed up.

Boilers are arranged three on a side facing each other with stairways, feed water heaters and coal hoist, located in one end of the building so that if at any time in the future it becomes necessary to extend the boiler plant it can be done with the least possible disturbance to the existing installation.

Equipment.

All the equipment in the plant is designed to operate at 200 pounds steam pressure and 125 degrees superheat, but due to a reduced load in the power plant, it was decided to run the boilers at 140 pounds pressure and supply steam to the mills, while the power plant load was light, in order to shut down other older and less economical boiler plants.

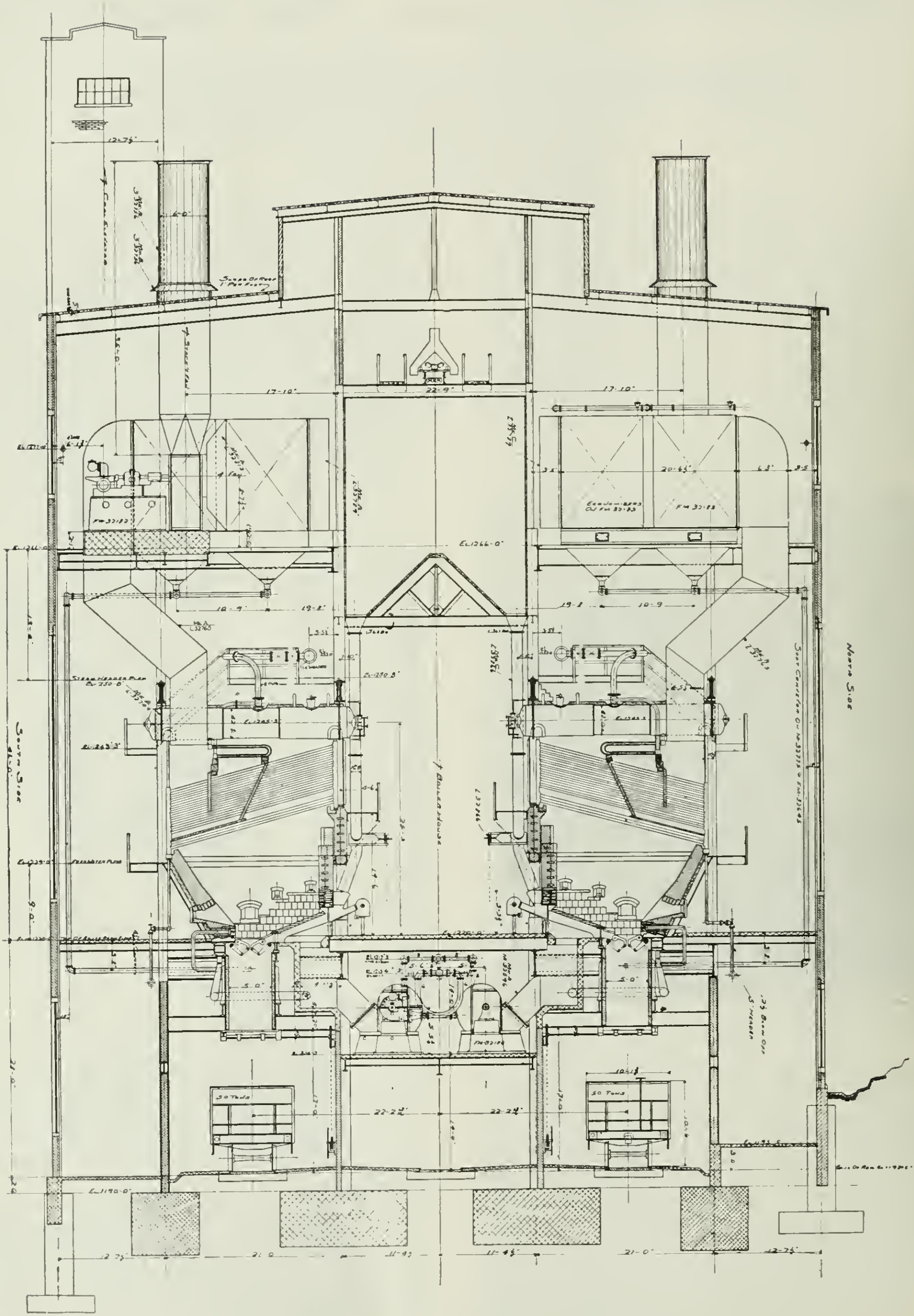


Fig. 3—Cross section through boiler plant.

The new plant consists of six 655 hp water tube boilers equipped with underfeed stokers, superheaters, soot blowers, automatic feed water regulators, fuel economizers, draft regulators, forced draft and induced draft fans.

Coal Handling.

Fig. 2 shows a general arrangement for feeding the coal from the track hopper into the skip bucket. The coal is dropped from a hopper car into the track hopper of 40 tons capacity, and from there into a three-ton skip hoist. The coal flows from the track hopper into the feeding device "A" when this device is in the position shown by dotted lines. The bucket "B" is equipped with an angle on the side nearest "A," which engages with the bar "C" when bucket is being lowered into pit. This bar "C" is connected by cable with the cam "D" and, as bucket lowers it turns the feeding device "A" into full line position and coal is transferred from "A" to "B." When bucket rises, the roller "E" on bucket engages "A" and returns it to dotted line position which allows coal from track hopper to again flow into "A."

When the skip bucket reaches the top of the building, the coal is transferred from it to an inclined 20-inch wide belt conveyor to the main belt conveyor over the coal bin. This conveyor is equipped with a tripper so that coal can be placed in the bin wherever desired. The coal bin has a capacity of 1,000 tons or about a 60 hours supply.

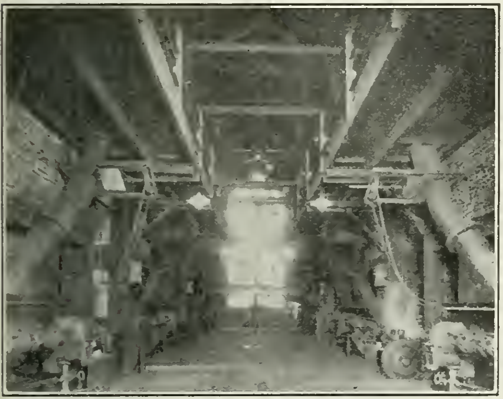


Fig. 4—General view of interior of plant.

Ash Handling.

Fifty ton standard gage ash cars are run directly under each side of the boiler house, as shown on Fig. 3, and the ashes are dropped into them from the ash hoppers underneath the rear end of the stokers, each ash hopper is equipped with two ash gates 5 x 5 feet running back and forth on a track. These gates were originally equipped with a hand operated mechanism which was not satisfactory and air operated cylinders are now being installed. The capacity of each ash hopper is 14 tons.

Stokers.

There are eight retort underfeed stokers, 17 tuyeres, 152 square feet of actual grate surface. Stokers are driven by a two cylinder steam engine guaranteed to work on a minimum pressure of 100 pounds gage. As the furnace height is 14 feet a large combustion chamber is provided. All dump grates are also operated by steam cylinders. There are two observation doors and one furnace door on each side of the furnace. Two observation doors on the front and two furnace doors through the rear or bridge wall of the furnace.

The usual number of retorts for this size boiler is six, but it was decided to install eight so as to get as high rating as possible out of the boilers. These stokers are guaranteed to burn sufficient coal to develop 250 per cent of rating for 24 hours duration and 350 per cent of rating for a period of four hours duration.

Forced Draft Fans.

The forced draft fans are radial flow fans with a speed of 850 rpm at 200 per cent and 1,532 rpm at 350 per cent rating, their maximum capacity is 40,000 cubic feet per minute.

Induced Draft Fans.

The induced draft fans are radial flow, single inlet type, with a speed of 420 rpm at 200 per cent rating and 755 rpm at 350 per cent rating, maximum capacity 62,300 cubic feet per minute.

The fans are driven by single stage turbines direct connected to the forced draft fans while the induced draft fans are driven through suitable reduction gears.

Feedwater Heaters.

The two feed water heaters are of the cylindrical atmospheric type, each 7,000 hp capacity. They are equipped with "V" notch measuring devices and covered with 2-inch insulation.

Economizers.

The economizers are extra heavy, cast iron, each composed of 288 tubes arranged in 48 sections, each section containing 6 tubes approximately 12 feet long, total net heating surface of each economizer 4,707 square feet. They are designed for a working pressure of 250 pounds which is 50 pounds above the actual pressure at which the plant will operate and are insulated with 2-inch asbestos sheets and each economizer equipped with five side dampers and two 3-inch relief valves.

Each economizer has three soot hoppers emptied by steam jet soot conveyor, the soot being discharged to a baffle box in ash cellar located over the ash cars and drops from box direct into cars. They are also equipped with mechanical scrapers driven by a five hp motor. A vertical louvre damper is placed between the economizer and the induced draft fan. This was installed to facilitate regulation and also to assist in banking fires for even with no great height of stack above the induced draft fan, the top of the stack is at a sufficient height above the grate to produce quite a natural draft.

Regulation.

The speed of the forced draft fans is governed by a balanced valve in the steam line to the fan, this valve being controlled by a compensated regulator actuated by the steam pressure in the main steam line.

The induced draft fans, damper and stoker engines are controlled by a cylinder and plunger actuated by compressed air, the control for the cylinder is a diaphragm on the side of the furnace wall connected to a pilot valve which alternately fills the cylinder with air and exhausts it as conditions may require. The diaphragm is connected to the furnace and is adjusted so as to maintain a balanced draft in the furnace.

The regulating equipment has worked satisfactorily although it was necessary to equip the stoker engines with a different type and larger size governor, than was originally furnished, in order to procure the desired regulation.

Boiler Feed Pumps.

The three boiler feed pumps are four stage centrifugal pumps driven by single stage steam turbine, suction and discharge are each 4-inches in diameter. These pumps when operating at 2,500 rpm will deliver 400 U. S. gallons per minute against a head of 635 feet with an efficiency of 58 per cent requiring 110 brake hp.

Steam Piping.

The steam and hot water piping is equipped with Van Stone flanges and metal gaskets, all branch connections are welded. The piping is covered with 2-inch thickness of sponge felt wrapped with canvas.

The Company has started the erection of another boiler plant at their Franklin Works in which the equipment is all of the same design and manufacture. However, there will be eight boilers, 977 hp each, and the rest of the equipment is in the same proportion.

New Boiler Feed Water System

Feed Water System Recently Installed at the Oliver Iron & Steel Company's Plant Shows a Large Saving In Maintenance of Boilers.

THE water supply for the entire plant of the Oliver Iron & Steel Co. is taken directly from the Monongahela river through an intake equipped with traveling screens. The main supply pumps discharge the river water into a standpipe from which it is distributed for all mill uses and for boiler feed.

For a number of years only nominal precautions were taken to protect the boiler equipment against the scaling and corroding effect of the impurities in the water. At this plant they have five locomotives, three of which are standard guage and two are narrow gauge. There are three stationary boiler plants, one with Babcock & Wilcox boilers, one with Cahall vertical boilers, and one with Heine and Babcock & Wilcox boilers. During the stress of the war period a very great deal of trouble was experienced in keeping the boilers and locomotives in service. The locomotives were a constant care and practically every Sunday these locomotives had to be gone over to either reroll or replace tubes and make other repairs, as well as to clean out the mud and scale that could be removed. This required the services of two enginemen, two firemen and a boiler maker.

In the stationary boiler plants, the tube losses were heavy and, notwithstanding frequent turbining to remove scale, there was great difficulty in keeping the boilers in condition to supply the necessary amount of steam for the power required to secure full production from the plant. The officials of the company finally determined to investigate the merits of softening and standardizing the boiler feed, and after an investigation of some of the other manufacturing plants on the Monongahela river where efficient water softening systems were installed, they purchased a 20,000 gallon per hour We-Fu-Go Water Softening and Purifying System from Wm. B. Scaife & Sons Co., Pittsburgh, Pa. This We-Fu-Go Water Softening and Purifying System was designed to fit in with their water supply system and the plant operating conditions.

The general design of the system is shown by the accompanying photographs. This compact arrangement of the equipment occupies the least ground space and by enclosing the foundation structure under the tanks, a building is provided that accommodates all of the piping, all of the mechanical equipment, the pumping equipment, the necessary storage of reagents and a receiving basin for the softened and purified water. It is located so that the raw water can be supplied to it by a gravity flow from the main supply standpipe.

In designing the system, it was found necessary to keep the top of the reaction-settling tanks within 36 feet of the yard level, so as to fill the tanks by gravity flow from the standpipe. The design of the foundation with the operating floor and chemical storage floor at an elevation of 4 feet above the yard level made the basement level, or pump and pipe gallery floor, 4 feet 6 inches below the yard level. The head room over the operating floor is approximately 8 feet under the beams. It will be noted from the exterior view that the construction is reinforced concrete columns and beams with brick curtain walls between the operating floor and the roof slab supporting the reaction-settling tanks.

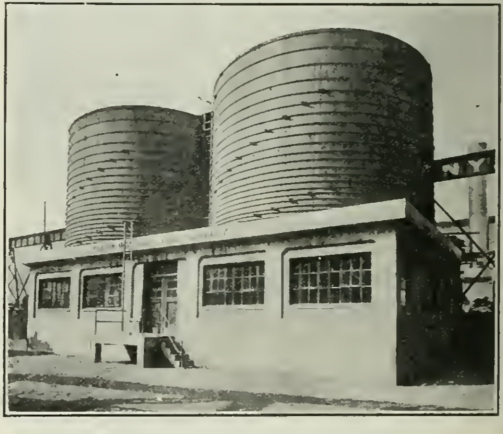


Fig. 1—General view of new plant.

The We-Fu-Go System consists of two reaction-settling tanks holding 80,000 gallons each. These tanks are equipped with mechanically operated stirring devices, driven by individual motors, direct connected through reduction gear.

The equipment for the tanks includes the necessary pipe connection for filling and sewer connection to flush out the accumulation of precipitates resulting from softening. The piping equipment also includes a hinged floating outlet pipe arranged to rise and fall with the level of the water in the tank. As the water is drawn from the tank, the outlet pipe falls with the level of the water. This hinged floating outlet pipe is provided with a stop to hold the pipe above the zone of settled sludge.

The tanks are also equipped with recording altitude gauges that show the complete cycle of operation; the time required to fill a tank, the time the tank is settling, the time during which the tank is emptied, the time when samples are drawn for testing and the time when sludge is removed. Each tank is also equipped with a high water alarm bell to notify the operator when a tank is full. Small pipe connections are run from the tanks to the gauge board for drawing samples for testing.

A small steel tank, equipped with a mechanical stirring device for mixing reagent solutions and a steam jet pump for delivering them into the reaction-settling tanks, is also included.

Two special gravity filter units are included. These are rectangular concrete tanks that are incorporated in the building. These filters are equipped with patented brass strainers screwed into pipe manifold. A layer of gravel covers the strainer manifold and over the gravel there are two layers of graded crushed quartz. Above the quartz bed there is a distributing trough for incoming water and for the collection of wash water during the washing period.

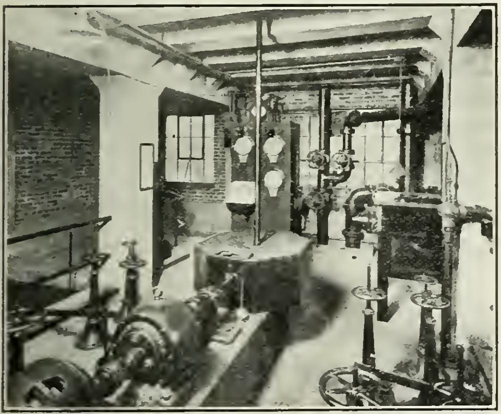


Fig. 2—Operating floor over piping gallery—Pump pit.

The filters are also equipped with specially designed air wash manifold to secure efficient agitation of the filter bed so that it can be washed with water under low head and with a minimum quantity.

The filters are equipped with low water alarm bells so that when a reaction-settling tank is emptied, the fall of the water level in the filter rings the bell to call to the attention of the operator the necessity for turning in water from the other tank. The water from the floating outlet pipe of the reaction-settling tank is delivered to the filters through a float controlled balanced valve. While the water is being supplied from the reaction-settling tank, the level in the filter is maintained and the inlet valve held open. When the reaction-settling tank empties, the level in the filter falls and at a determined low level rings the bell.

The discharge from the filters is connected to the purified water basin and the high water level in this basin corresponds with the high water level in the filters, so that the water level in the basin automatically controls the rate of filtration. When the basin is filled, the filter fills so that the inlet valve in the supply line from the reaction-settling tank is closed and the water is thus held in the reaction-settling tank until the level in the purified water basin is lowered to permit the delivery of the water from the filters. Each filter outlet is provided with a float controlled balanced valve, so that if the supply from the settling tank is exhausted and the level in the purified water basin drops, then the valve in the outlet line will close to prevent the filter from draining. This valve closes to retain sufficient head of water over the filter bed so that in turning in water from a full reaction-settling tank the surface of the filter bed will not be disturbed. The filters are located one on each side of the building with the bottoms of the filters at the same elevation as the bottom of the purified water basin. The pipe gallery between the filters is supplemented by a small room in which is located the centrifugal pumping units that deliver the purified water to an elevated storage tank, formerly part of a water treating system; from this tank the purified water is distributed to the boiler houses and for the locomotives.

The purified water basin, the pipe gallery between the filters and the pump pit are floored over. The space over the purified water basin is separated from the other floor space by a partition, and in this room are stored the chemical reagents. In this room is also located the reagent mixing tank. On the floor extending over the pipe gallery and pump pit are located the gauge board, sampling faucets, the electric switches and hand wheels for operating all valves of the main piping.

In the operation of the system the reaction-settling tanks are filled alternately, and while a tank is filling the reagents are introduced and thoroughly mixed with the water by means of the stirring devices. After a tank is filled and the treatment completed, the stirring device is stopped and the water becomes static, allowing the precipitated lime, iron and magnesia to settle to the bottom of the tank. The softened and settled water is taken out of the tank by means of the hinged floating outlet pipe. The rate of flow through this pipe to the filters is automatically controlled so that the delivery of the water from the filters to the purified water basin controls the time of emptying. While one tank is being filled, treated and settled, the other tank is supplying treated water. With this system, a reaction-settling tank will supply the rated capacity for a period of four hours, and during this period the other tank can be filled, treated and settled with ample time allowance for reaction and settling before the water is drawn.

In addition to the settling period prior to beginning to draw water, there is an additional four hour settling period while the floating outlet pipe follows the lowering water level in the reaction-settling tank.

The reaction-settling tanks are really measuring tanks, and by working with a measured volume of water an absolute control over the softening functions is maintained so that notwithstanding the extremely wide variations occurring in the quantities and amount of impurities to be removed, a standardization of the water is obtainable.

In this system the following essentials for exact and uniform softening and purification are embodied. These include:

Accurate treatment derived from the actual reaction values of the various reagents in a fixed volume of water under treatment.

Thorough mixture of reagents with the water and also a thorough mixture of the precipitates of previous purification that become nuclei to assist reaction for the formation of new insoluble precipitates.

Accelerated chemical reaction due to the thorough mixture of reagents and precipitates by positive mechanical stirring during the entire period that reagents are being introduced.

Complete chemical reaction to stabilize the residual calcium and magnesium so as to inhibit any subsequent precipitation from change of temperature or agitation.

Rapid and complete sedimentation by having the water quiescent during the settling period.

The removal of colloids and perfect clarification by efficient filtration with the water under a uniform static head over the filtering media.

The water in the Monongahela river varies through an extremely wide range both as to the amount of incrusting solids in solution and the suspended matter, and also in the range between an alkaline stage and an acid stage. From a large number of analyses over a period of 15 years, it shows that the minimum of incrusting solids is 3.5 grains per gallon and the maximum 31.0 grains per gallon. During the same period there was at times an alkalinity of 1.4 grains per gallon and at other times, an acidity as high as 3.72 grains per gallon. The suspended matter varies from a negligible quantity to an extremely muddy stage. Even with such wide variations in the soluble and suspended impurities, a standardized water is obtained with the We-Fu-Go System. The softened water is of uniform alkalinity in which the residual soluble calcium and magnesium are a negligible amount and in such combinations that they do not form scale.

The analysis of the water before and after softening, show the calcium and magnesium content to be as follows:

RAW	SOFTENED
Calcium and magnesium Incrusting solids Grains per gallon	Residual total of calcium carbonate and magnesium hydroxide Grains per gallon
6.73	1.13

These analyses in comparison with analyses from eight other similar systems show that in softening the Monongahela river water by this method, the variation in the soluble calcium and magnesium is kept within a range of ½ grain per gallon with a similar control of the alkalinity.

The application of this standardized softened water to the locomotive boilers at the Oliver plant has resulted in the elimination of Sunday work, and all the attention that they have required has been about three hours per week to wash out. The net saving in the maintenance of the locomotives has approximated $100.00 per month. Water taken from the locomotive boilers at the semi-monthly washout is as clear as crystal. Several new sheets were put into the water tank of one of the locomotives and this has now been in use for five months and the surface is absolutely clean.

The boilers in the stationary plants were given a complete cleaning just prior to starting the use of softened water. They have now been in operation five months, and in that time no foaming troubles have been experienced, there has been no scale accumulation and no losses of tubes. The maintenance on the stationary boilers is reduced in the same ratio as that obtained on the locomotive boilers. The results obtained are in complete accord with what was anticipated in the report upon which the installation of the system was authorized.

Present Status of Powdered Coal

Its Application As a Fuel for Boilers — Series of Tests Are Included Which Illustrate the Results Actually Obtained in Burning Various Grades of Coal.

By CHAS. LONGENECKER.

ENGINEERS generally appreciate the limitless field open to powdered coal as a fuel for boilers. In the past there were many divergent views as to the economy which could be obtained by this method of burning coal but developments have demonstrated beyond doubt that very substantial economies can be effected. That there would be contradictory reports is only natural as this always is the case attending the introduction of any method or process which involves a radical departure from established practice. Again it must be borne in mind that previous to 1913 no serious attempt was made to apply powdered coal to boiler furnaces and in fact the history of powdered coal as a boiler fuel has been almost wholly confined to recent years.

In 1913 at the Henry Phipps power plant in Pittsburgh the so-called Blake process was tried out. The form of application is shown in Fig. 1. Those conversant with present-day practice can readily appreciate the defects in the construction of the combustion chamber but the vertical position of the burner is the same as is used today. Like all early attempts to apply powdered coal failure can be attached in practically every case to lack of the necessary volume and to the incorrect form of the combustion chamber. A test run on the boiler equipped as shown is reported as follows:

Duration of test	6 hours
Total weight of coal fired, pounds	5,160
Total weight of water, pounds	56,160
Average temperature of feed water	186 deg. F.
Average steam pressure	162.3 lbs.
Factor of evaporation	1.084
Water evaporator per pound of coal	10.88 lbs.
Water evaporator per pound from and at 212 degrees	11.725 lbs.
Boiler efficiency	78.93
Calorific value of coal	14,350 Btu.
Horsepower of boiler	294.6
Builders' rating	300
Temperature of escaping gases	386 deg. F.
Cost of coal 2.58 tons at $1.315 per ton	$3.392
Cost of coal per pound	.0006575
Pounds of coal per boiler horsepower per hour	2.92

There are two systems now employed for preparing the coal and delivering it to the furnaces. In one system, as illustrated, the coal is pulverized and distributed direct by one machine. The second system drys and pulverizes the coal in separate pieces of machinery and it is then carried to the furnace in a current of air generated by a fan. The coal is not dried in the first mentioned system.

Whatever the system employed for preparing and distributing the coal it must, to be successful, be responsive in control and admit of exact adjustment as regards the coal and air supply. Proper mixing of coal and air is likewise vital to economic operation. A system which fulfills these requirements will answer the purpose as far as furnace conditions only are considered. Viewed from a broader standpoint, with emphasis on economy of operation of the plant as a whole, the cost of power, labor, repairs, etc. must be taken into account. There is thus a natural division of the subject as follows:

1. The furnace and boiler as one unit and
2. The coal handling equipment, from car to burner, as a unit.

In considering the first subdivision the boiler is standard. In all development work no boiler, with one exception, has been brought out to better meet the needs of powdered coal firing. The one exception is the Bethington vertical boiler which was never used to any extent.

The furnace is the most important feature of all installations and has been the subject of the greatest amount of research. It is here that the real problems are found. The success attained by any powdered coal installation will be determined by the design of the combustion chamber and this in turn must be based on a correct interpretation of the principles governing the particular combustion characteristics existing. Not only must the volume be sufficient but the form must likewise be correctly proportioned. In some cases there is not much latitude for shaping the furnace due to limits imposed by the equipment to which the application is to be made. The shape of the furnace interior will, in all cases, have to conform to lines which local conditions determine. These limitations exist only where it is necessary to apply powdered coal to furnaces formerly fired by hand or by stokers. Where the complete installation is new including boilers, etc., there will be the utmost freedom in design. Another feature which complicates the combustion chamber layout is that in most cases the rating of the boiler will vary and the design must be such that the greatest efficiency will be secured with the varying rating.

As regards the actual burning of the coal the points demanding attention are the slagging or non-slagging of the coal ash, the length of travel of the flame, the protection of the brick work from impinging flame, the manner in which the secondary air is introduced, the precipitation of the ash, temperature control, etc. With so many variables to be correctly coördinated need of exact knowledge is readily appreciated.

In most of the early installations the coal was carried into the furnace through a burner horizontally placed. Some of the present-day installations still adhere to this construction but generally the burner is placed at the top of the combustion chamber which extends out from the front of the boiler. With a chamber of sufficient depth this will give length of travel to the flame which is difficult to secure with the burner in a horizontal position.

There still exists some difference of opinion as to the disposition of the ash. Some engineers prefer to dispose of this as a slag while others do not permit the ash to fuse. The fusing point of most ashes is about 2,200 degrees F. Some fuse at 1,800 degrees F. while others require a temperature of 2,600 degrees F. While in a pasty state the ash cannot come in contact with the boiler tubes as it will adhere and naturally cause trouble. If the ash can be sufficiently cooled before coming in contact with any surface it can be taken off in a flaky or granular condition. The temperature of the flame varies from a point of very low temperature near the burner opening to a very high temperature near the "tip." The combustion chamber must be so proportioned that the point of highest temperature of the gases is not too close to the brickwork. If such is the case, there will be slagging of the brickwork and erosion which will increase furnace upkeep.

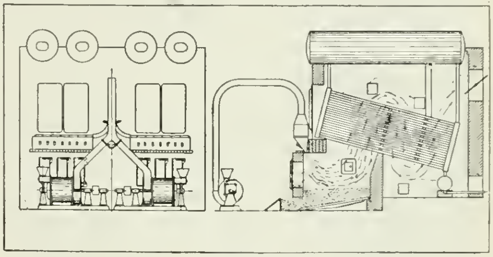


Fig. 1.

Another feature which has been one of some controversy is the question of proportioning the quantity of excess air. In some cases more air has been admitted than actually required by the coal for combustion. The object of admitting this excess air is to reduce the temperature of the gases so that "cutting" of the brickwork will be prevented. This procedure is contrary to the elementary principles governing the economic combustion of fuels but in practice it has given satisfactory results. In Table 1 the quantity of excess air can be noted from the flue gas analysis. This is very low with the exception of tests No. 6 and 7 where the excess oxygen is 15.9 per cent and 18.2 per cent. In these cases the large amount of excess air admitted was not accidental but entirely premeditated. It was found in this particular installation that better results were secured. The test report states in regard to this feature on these tests "with a higher CO_2 the furnace temperature became too great causing slagging and fusing of the brickwork and the evaporation fell off." In a series of tests recently reported in the May issue of the American Society of Mechanical Engineers, the highest percentage of excess air was 30 per cent while the average was 21 per cent. This shows how little excess air is actually required to fulfill the combustion requirements and the economy with which coal can be burned. The draft created by the stack and pressure of the air carrying coal from the burner are features which must be carefully adjusted to give the most satisfactory results.

Table 1 gives a series of tests chosen to illustrate the results secured when burning different grades of coal. These give some idea of the practice at different plants

Table No. 1.

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9	Test No. 10	Test No. 11	Test No. 12	Test No. 13
Duration of test—hours	6	12	7	99	9	24	11	6.20	5.88	22.9	23.6	22.47	23.33
Water heating surface, square feet	4862	5334	4862	5274	4680	6144	6144	2357	2357	5274	5322	5322	5322
Volume of combustion chamber, cubic feet.	..	1678	..	1678	..	2000	2000	....	....	1660	1660	1660	1660
Steam pressure gauge.	142.8	167	135.7	167.8	140	92.7	83	116.6	107.1	169.3	174.3	172.3	167.3
Temperature of steam, degrees F.	362.1	499	358	441.9	360.7	444.7	441	348	342	430	436	439	444
Temperature of feed water, degrees F.	135.6	170.1	105.4	156.3	82.49	155.6	165	194	197	108	101	100	100
Temperature of stack gases, degrees F.	447.2	478.2	465.3	496.6	582.2	248.3	252.5	562	630	517	483	472	466
Horsepower of boiler.	486	468	486	468	468	520	520	250	250	468	468	468	468
Horsepower developed	561.2	550.9	809	554	711	677	779	304	353	514	589	601	487
Percent of rated capacity developed	115.2	117.7	166.5	118.4	152	130.1	149.7	121.6	141.3	109	126	128	104
Water evaporated from and at 212 degrees per pound of fuel as fired	10.61	8.50	9.79	10.58	9.7	11.27	10.18	8.86	10.33	9.79	9.14	8.97	8.66
Dry coal fired per hour	1786	2220	2836	8978	1530	2067	2615	1102	1073	1756	1973	2024	1785
Boiler efficiency	79.62	83.33	85.01	80.67	83.27	77.20	82.32	75.5	80.7	81.9	81.7	81.6	80.5
Equivalent evaporation from and at 212 degrees per square foot of heating surface	3.98	4.06	5.74	4.09	..	2.14	2.57	4.44	5.17	3.67	3.85	3.87	3.30
CO_2 in flue gases	14.34	..	14.3	12.26	14.8	7.62	7.7	11.96	10.0	14.10	15.50	15.8	15.8
O in flue gases	4.81	..	5.2	6.82	3.17	15.9	18.2	..	..	4.80	3.30	2.40	2.90
CO in flue gases	00	..	00	00	..	.19	.1	..	..	..	..	.10	.00

KIND OF COAL	Anthracite	Ill. and Ind.	Anthracite	50% Yough. and 50% Kent.	Texas Lignite	West Va.	West Va.	Coke Braize	Anthracite				
Volatile Matter	10.39	..	8.35	32.13	..	32.66	30.21	9.89	8.55	36.62	36.58	36.29	34.42
Moisture	2.15	8.5	1.32	7.27	..	.79	.84	.99	1.25	1.42	2.55	3.07	8.23
Fixed carbon	74.45	..	64.90	49.60	..	56.51	50.29	73.76	78.30	48.16	48.07	49.01	46.39
Ash	13.01	15.89	25.42	11.04	..	10.83	19.50	15.36	11.90	13.80	12.80	11.63	10.96
Sulphur	.88	..	.89	1.62	..	1.50	1.24	..	..	2.66	2.92	2.66	2.21
Calorific value of one pound of coal	13232	9971	11227	12810	11315	13147	11610	12190	13289	11956	12085	12178	11508

HEAT BALANCE.

Heat absorbed by boiler	79.46	83.33	85.01	80.67	83.27	83.33	85.85	75.5	80.7	81.9	82.7	81.6	80.5
Loss due to evaporation of moisture in coal	.20	..	.06	.06	..	.066	.078	..	..	0.1	0.2	0.3	0.9
Loss due to heat carried away by steam formed by burning of hydrogen	2.81	..	2.01	3.79	..	3.91	3.91	..	..	4.1	4.1	4.2	4.1
Loss due to heat carried away in dry flue gases	8.83	..	10.72	11.93	..	6.39	6.79	..	..	10.8	8.9	8.6	8.5
Loss due to carbon monoxide	00	..	00	00	..	1.18	.585	..	..	..	0.1	0.2	0.0
Loss due to combustible in ash and refuse	1.27	..	00	.18	..	0	..	..	..	.6	0.4	0.7	0.3
Loss due to heating moisture in air	0.11	..	.09	.30	..	.283	.295	..	..	0.3	0.1	0.1	0.1
Loss due to unconsumed hydrogen and hydro-carbons, to radiation and unaccounted for	7.32	..	2.11	3.07	..	4.77	2.04	..	..	2.8	3.5	4.3	5.6

Tests Nos. 2, 4, 6, 7, 10, 11, 12 and 13 have superheaters.
Tests Nos. 6 and 7 have economizers.

where coals of varying analysis have been burned.

One of the most frequent questions raised by those seeking information is as regards the ash content permissible and within what limits a coal must come in analysis. It is only possible to give results from experiments in answering this question as from time to time coals which appeared to be beyond the limits are being burned efficiently. The upper limit for ash as shown by the tests is in Test 3 where it is 25.42 per cent, in Test 7 the ash content is 19.50 per cent. The lowest percentage is in Test 6 which gives 10.83 per cent. Coals with ash as high as 33 per cent have been burned and have given no trouble as far as efficiency is concerned, but the continued firing of such a coal may give rise to difficulties in ash disposal. Another consideration which has a great influence on the success of a high ash coal is its point of fusion as previously mentioned. Again the question of ash disposal is a very frequent one. Here again each individual installation will have a different set of conditions and these will control the disposition of the ash a certain percentage will go up the stack while the remaining portion will be deposited in the combustion chamber and in the breeching, etc. Reports show in some cases 75 per cent passing out the stack while in other cases the amount is only 35 per cent. Investigations made to determine what detrimental effects follow from this ash passing out the stack are practically conclusive in reporting that the feature can be disregarded. The ash is so light that it is not precipitated in any quantity in any given unit of space.

Another point to be noted is that the "loss due to combustible in the ash and refuse" is practically nil. The highest loss reported is in Test 1 where it is given as 1.27 per cent. In all other cases it is practically negligible. This is certainly a fine index to the completeness of combustion and shows plainly one of the reasons why this method of burning coal must receive consideration. Powdered coal firing will eliminate the "smoke nuisance" beyond doubt.

The volatile matter may be as low as is generally found in anthracite coal or in coke and as high as contained in "gas coal." The table shows a coal with only 8.55 per cent volatile matter. Anthracite coal has been burned successfully and there is no doubt as to the efficiency attending. Coals with a high volatile content are readily ignited and burn very freely.

The moisture content may be quite high as it can be easily eliminated to a reasonable amount by drying. In Test 12 and 13 the coal was not dried but was fired "as received" as regard moisture. There has been a question raised as to whether it is necessary to dry the coal. This depends very much on the coal and its characteristics. No positive answer can be given to this question as in certain cases other considerations, which are indirectly connected, cannot be ignored. These considerations cover the effect of high moisture on distribution and pulverization. Then too, the coal from the East differs from those of the Central West in this particular and while Eastern coals need not be dried the Western must be. Eastern coals hold the moisture less tenaciously than the Western.

Sulphur need cause no trouble unless it exists in abnormal quantities as it is readily oxidized and passes off as SO_2. Sulphur is an index to the iron content if present as iron pyrites and this together with other factors will give some idea as to the fusibility of the ash. The fusibility depends upon what form of silicate is formed and the relative proportions of bases present.

Due advantage possessed by burning coal as a powder is that many coals which cannot be burned by other methods efficiently may be so burned if powdered. The lowest Btu. content per pound given in the table is 9,900 but coals having a lower calorific value may be easily burned.

The "loss due to carbon monoxide" is likewise exceedingly low and illustrates how closely the air and coal can be proportioned and mixed. CO is considered by most authorities to be a product of the reduction of CO_2 rather than the direct product of the oxidation of carbon CO_2 is first formed and then CO according to the equation $CO_2 + C = 2CO$. The oxygen of the air must unite with the CO after the reduction of the CO_2 if the gases are to show no CO in them. Temperature and air supply are both factors in completing combustion as the equation just given is reversible at certain temperatures. Evidently these are sufficient in degree and quantity in powdered coal firing.

The greatest loss is that "due to heat carried away in the dry flue gases." This is low as compared to other methods of burning coal. Other methods may equal these figures but they do not consistently average as low.

The temperature of the stack gases varies between 447 degrees F. and 630 degrees F. In Test 6 and 7 where economizers were used the temperature is only 248 degrees F. and 253 degrees F. There is a temperature below which is not permissible to fall if an adequate draft is to be maintained.

The boiler efficiencies are high and in some cases are higher than can be expected in normal every day operation. The boiler capacities in these tests are average and do not represent "peak loads."

The second item in the subdivision—the coal handling equipment from car to burner—functions steadily and admits of any adjustments relative to coal feed. The only question which may arise is that relating to economy of operation. In any comparison with other coal feeding methods the comparison must include the handling of coal from the car to the ultimate disposal of the ash. Too frequently such comparisons are incomplete in this particular.

The savings obtained by powdering coal are both in labor and in fuel. In many new plants a certain amount of work is required to get the machinery adjusted properly and get smooth operating conditions. The design of furnace must also be perfected to meet the conditions of the particular plant. This is the case in practically every plant whether the installation be one for powdered coal or some other installation of equipment of like nature. The cost of operation of a plant will of course be greater where it is not operated to capacity. In a plant where industrial furnaces and boiler furnaces are both fired by powdered coal, an additional saving results from the fact that all coal handling equipment is centralized. Each plant has certain features which differentiate it from others and hence costs will vary according to capacity of plant in tons per hour, kind of coal, type of equipment, etc.

The ability to burn coals varying greatly in moisture, ash, volatile matter, etc., is sure to open up an immense field and greatly reduce the cost of evaporation per 1,000 pounds of water. Bituminous and anthracite coal as well as Lignite and Peat have been fired under boilers with perfectly satisfactory results.

Scientific Boiler Feed Water Regulator

General Description and Use of a Boiler Feed Water Regulator. An Average Feed Water Temperature at a Constant Level is a Great Advantage to the Boiler.

By ROLAND MOELLER, M.E.

THE first efforts in boiler feed regulation aimed at keeping the water level in the boiler as nearly constant as possible. Later, in about 1912, it was realized that keeping the water level constant at all times had decided disadvantages.

Prior to that time, automatic boiler feed regulation depended on a combination of floats, pilot valves, diaphragms, springs, etc., which would give the feed water valve a full opening until a certain maximum water level had been reached in the boiler, and then would close off the feed water valve entirely, until a certain lowest limit in the water level had again been reached. This gave an irregular intermittent feed, which insofar as its effect on the generation of steam was concerned, was not much of an improvement over hand regulation.

While an automatic mechanical device that is absolutely reliable has never been made, there are many automatic mechanical devices which are far more reliable than a human being, especially where the apparatus is given a reasonable amount of care and attention. It is for this reason that a water regulator properly designed will add much to the safety of operating a plant.

A continuous flow of feed water with gradual variations in rate saves the boilers, heaters, economizers, meters, water pumps, piping, and all connection from shocks and strains due to violent and extreme fluctuations in the rate of feed water flow peculiar to many forms of old-style regulators.

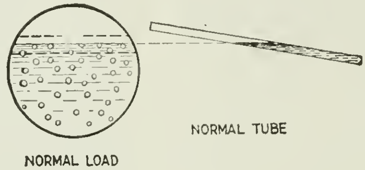


FIG. 1

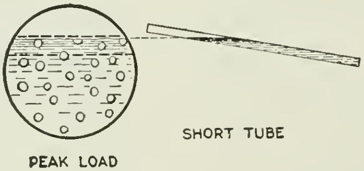


FIG. 2

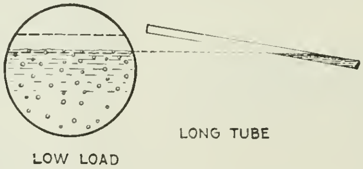


FIG 3

How the water level in a boiler, changing with the load, alters the length of that portion of the thermostatic tube which is exposed to hot steam.

The continuous flow also makes possible the use of smaller-feed pumps, feed water pipe lines, connections, valves, etc., because when the feed water supply is continuous, the rate of flow at any given time need not be as great as when water is fed intermittently.

As the equipment in boiler rooms became more and more involved with the addition of water softeners, economizers, feed water heaters, superheaters, temperature, steam and water meters and recorders, and other apparatus to promote economy and efficiency in the generation of steam, it became evident that the rate of flow in the feed water had a decided effect on the efficiency of all of this equipment and on the legibility of the charts produced by the various recording meters.

A water softener is calculated to handle a certain number of gallons of water per hour on the basis of a continuous even flow. Where the flow is intermittent and irregular, a much larger water softener must be installed to handle the same quantity of water, and its operation is far less satisfactory and economical than it would be if the flow of feed water were continuous and more closely in unison with the rate of steam output of the boiler.

The same is true of economizers and feed water heaters. When the flow of feed water through these is reduced, the feed water reaches an excessively high temperature, and may even turn into steam, resulting in water hammer and other troubles in the feed water system. The apparatus under these conditions allows heat to escape without being absorbed. On the other hand, when at intervals the feed water valve is opened wide, the feed water rushes through at such a high rate that it is not warmed up to a temperature commensurate with economical boiler operation.

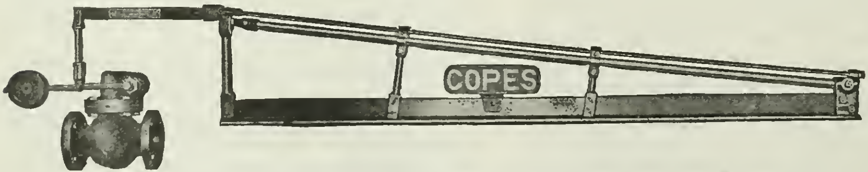


Fig. 4—The Copes Boiler Feed Regulator, showing details of the thermostat, feed water control valve, and connections.

The rate of feed water flow has a decided effect upon the steaming capacity of a boiler itself. A full opening of the feed water valve may pass enough cold feed water into the boiler to absorb all the heat generated by its furnace without generating any steam whatsoever. Intermediate rates of feed water flow will, of course, reduce the steaming capacity of a boiler in proportion to the flow of the feed water.

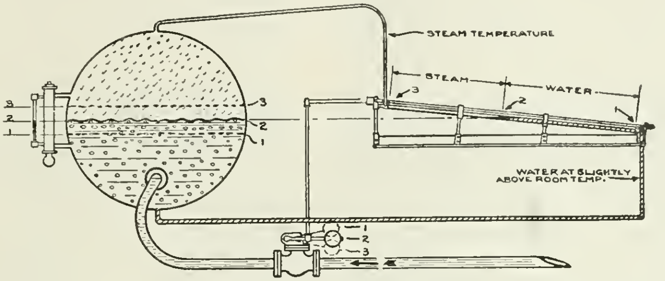


Fig. 5—Showing how the Copes Boiler Feed Regulator is connected to the Boiler, and how it works.

Bearing this in mind, it is evident that there are frequent periods in the operation of a steam boiler when it would be desirable to reduce the rate of feed water flow so as to make possible the maximum generation of steam. This is particularly true after a period of low load when a sudden peak load comes on. Under these conditions the furnace must be given time to catch up with the new peak load conditions, and, if during this time, the rate of feed water flow is temporarily reduced, the boiler has a far better chance to meet the sudden increased demand for steam, when little heat is being consumed in heating up feed water to the boiling point in the boiler.

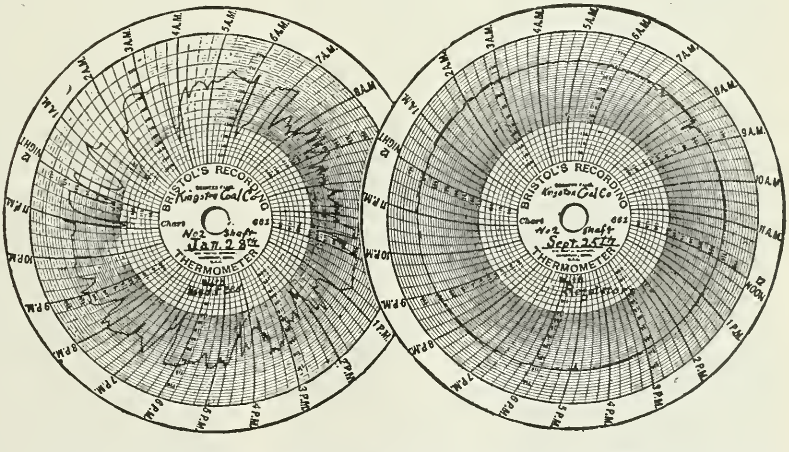


Fig. 6—Typical before and after time-temperature charts, showing an average increase in the feed water temperature of 32 degrees, equivalent to a saving of 3 per cent in fuel, resulting from the installation of the scientific Copes System of Boiler Feed Regulation.

On the other hand, should the load suddenly drop off after a high load period, it takes some time for the furnace to slow down to where it generates heat at a rate in harmony with new load conditions. It is then desirable to increase the rate of feed water flow temporarily so as to absorb the extra heat generated by the furnace during this brief period.

Again, where a large number of boilers are acting in unison, fewer boilers can be made to do the same work that would ordinarily require a larger number of boilers laboring without scientific feed water regulation. With unscientific feed regulations, the steam output of some of the boilers may be so affected by the admission of feed water during a high load crises, that their addition to the total steam supply is very much curtailed or even reduced to zero when it is most needed. With scientific regulation on the other hand, all the boilers would be delivering their maximum output, the rate of feed water flow being reduced to a minimum in all of them at the same time to make this possible.

A good automatic feed water regulator should, then, feed continuously as long as there is a load on the boiler. It should temporarily reduce the rate of feed water flow when there is a sudden increase in load and temporarily increase the rate of feed water flow when there is a sudden decrease in load. It should keep the water level high under low loads and low under high loads. During steady loads it should maintain a constant water level by manitaining a constant rate of feed proportionate to the load. During gradual changes in the load, it should gradually adjust the rate of feed in proportion to the changes in the boiler load.

A regulator functioning on these principles acts as a sort of compensating boiler governer, that is, it supplies the means of absorbing the excess heat generated by the furnace during the brief period following a sudden falling off of the load when the furnace has not yet had time to adjust itself to the new conditions. It prevents the absorption of heat by the feed water when the furnace has not yet had time to catch up with a sudden increase in load, and all the heat that is generated is required for steam making. It utilizes the volume represented by the difference in the levels of the water between the high and low water marks in the boiler as a sort of heat reservoir, and so regulates the water level as to insure dry steam at all times. It guards against damage due to too high or too low water level at any time.

It has been conclusively demonstrated that the water level of a steaming boiler undergoes pronounced fluctuations which have a direct relation to the rate at which it is producing steam. This is due to the increased volume of steam bubbles present in the water when the steam output of the boiler is high. Illustrations, Figs. 1, 2 and 3, show the variations in the water level in a steam boiler containing the same weight of water under normal, peak and low load conditions. This variation of water level according to load is one of the characteristics of steam boilers utilized in the type of regulator shown in Fig. 4.

A regulator of this construction is extremely simple, consisting merely of a straight tube, a lever, a heavy iron base, and a ruggedly balanced, practically frictionless valve. Such a regulator is easily adjusted to maintain the water level between any desired limits. The connections to the boiler as shown in Fig. 5 are of the simplest, so that any help ordinarily found in the boiler room can install it.

In this feed water regulator a metal tube having a large coefficient of expansion is connected to the boiler in such a way that the level of the water in this tube varies with the level of the water in the boiler. The water in the lower end of the table, not being exposed to any source of heat, becomes comparatively cool, while the upper end of the tube above the water level is kept hot by steam from the boiler to which it is connected. As steam slowly condenses in the upper part of the tube, it is returned to the boiler through the lower end. If the water level in the boiler suddenly rises, due to an increase in load as in Fig. 2, the level of the water in the tube also rises and the length of the tube above water containing hot steam is reduced. If, on the other hand, there is a dropping off of the water level due to a decrease in load as in Fig. 3, the length of the tube exposed to hot steam is increased by the amount the water level recedes in the tube. The portion of the tube which is exposed to the hot steam expands, and the greater the length that is so exposed, the greater the increase in the overall length of the tube. This difference in the overall length of the tube between high or low water is utilized to operate a valve which controls the rate of flow of the feed water.

When there is a sudden increase in the demand for steam, the water level in the boiler rises. The length of the tube exposed to the hot steam is decreased and the length exposed to the cooler water is increased. Consequently there is a contraction, and the overall length of the tube is decreased and this in turn reduces the opening of the feed water valve. If the high load continues, the level of the water will of course gradually drop off until the water level in the tube comes to a point where the feed water valve begins to open. The opening increases gradually until a uniform rate of feed is reached, which is equivalent to the rate at which the water is used up in making steam. If the demand for steam is high, the demand for feed water is high, and the feed water valve must have a wide opening. To get this, the tube must expand more. This in turn can only be brought about by a lower water level, and that is exactly what is desired under high load conditions.

If, on the other hand, the demand for steam suddenly drops off after a continuous high load, the water level in the boiler falls immediately, and with it the level of the water in the tube. The length of the tube exposed to hot live steam is increased, causing an increase in its overall length. This in turn opens the feed water valve so as to admit water to the boiler at a greatly increased rate until not only the former level is reached, but until the level is higher than the one under high load conditions. To reduce the flow of feed water to conform to the reduced demand for steam, the opening of the feed water valve must be reduced to less than it was when the demand for steam was high, and to accomplish this, the thermostatic tube must contract more. It does this only with a rise in the water level. Higher water level during low loads is very desirable for heat storage purposes as explained before, and is entirely permissible with light loads.

The two time-temperature charts shown in Fig. 6 are typical before and after records where one of these automatic thermostatic boiler feed regulators replaced hand regulation. The left-hand diagram shows an average feed water temperature of 178 degrees, which was the best obtainable with hand regulation. The right-hand diagram shows an average feed water temperature of 210 degrees, which resulted with automatic continuous flow regulation based on the principle here set forth. The average feed water temperature was therefore increased 32 degrees F., which is equivalent to a saving of 3 per cent in fuel.

RECENTLY DEVELOPED STELLITE PRACTICE—ESTABLISH NEW RECORDS.

(Compiled in Text Book Form for the First Time)

The remarkable cutting qualities of Stellite, which contributed so largely to speeding up production during the war are pretty generally known. What Stellite is doing to aid peace-time production, however, and the recent developments that have improved and extended its application are not so widely known. There are still some users of high-speed cuting tools who regard Stellite as an alloy of steel; unfortunately, they have tried to use it as they would high-speed steel, thus failing to obtain its full advantages. The new production records established with Stellite tools have created a demand for authentic information and specific facts concerning Stellite's advantages as a cutting metal.

Two new books, just issued by the Haynes Stellite Company will admirably satisfy this demand. They are text-books in convenient pocket size, containing valuable information never before published. They tell all about Stellite in an unusually interesting and instructive way. New method of obtaining increased speed—the latest advances in machine-tool practice—heat charts—tables—complete data and exceptionally fine illustrations are all graphically presented. There are many departures from the ordinary practice, which should make a careful study of the contents well worth while.

The completeness of the instructions and illustrations covering this new and successful machine-tool practice, make these text books a valuable addition to the working library of every shop superintendent and machinist.

The announcement of reliable text-books explaining the application of tools, whose speed is not limited by the heat from cutting, will be of unusual interest and value, coming at this time when it is so vitally necessary to get the utmost production at the lowest possible cost.

Copies of these new hand-books may be obtained without charge by writing to the Haynes Stellite Company, 30 East Forty-second Street, New York City, for volumes 9 and 10 of their Stellite reference library.

Magnetic Separator Pulleys in Coal Plants

The Use of This Equipment is Now Very General in Coal Pulverizer Plants—Details of Construction and Use of Magnetic Separator Pulleys.

By W. H. COSTELLO.
Engineer, Cutler-Hammer Manufacturing Company.

COAL delivered to the pulverizing plant contains a considerable amount of tramp iron in the form of bolts, nuts, rivets, nails, bar iron, mule shoes, hammer heads, etc. Any of these materials entering the pulverizing mill will result in damage to the machine with consequent delays in operation. To remove this iron, some form of electro magnet is used. Several types of magnets were tried out during the development stage of pulverizing equipment, resulting in the early recognition of the pulley type as the most satisfactory and efficient. Magnetic pulleys are now listed as standard equipment by manufacturers of coal pulverizing equipment.

The magnetic pulley serves as the head pulley of a belt conveyor and may be installed on any one of the belt conveyors ahead of the pulverizer mills. The magnetic pulley is sometimes installed ahead of the coal crusher, although it usually is not necessary to protect the crusher from iron.

Illustration No. 1 shows diagrammatically the course through which the coal passes in the pulverizing plant from the incoming hopper to the pulverizer mills. The lump coal is discharged from the railroad cars into receiving hopper below the track. From the hopper the coal is conveyed to the crusher, which breaks the coal to about 1-inch size. The crushed coal is then elevated and discharged onto a belt conveyor serving the dryer storage bin. A magnetic pulley serves as the head pulley of this conveyor. After passing through the dryer the coal is elevated to storage bins, from which it is delivered to the pulverizer mills.

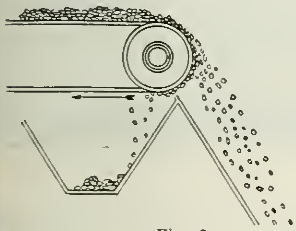


Fig. 2.

The action of the pulley is shown in illustration No. 2. When the coal passes over the magnetic pulley, the tramp iron is attracted and held firmly against the belt and remains in contact with the belt until withdrawn from the magnetic zone. The iron then drops into a bin under the pulley, while the coal continues on its course.

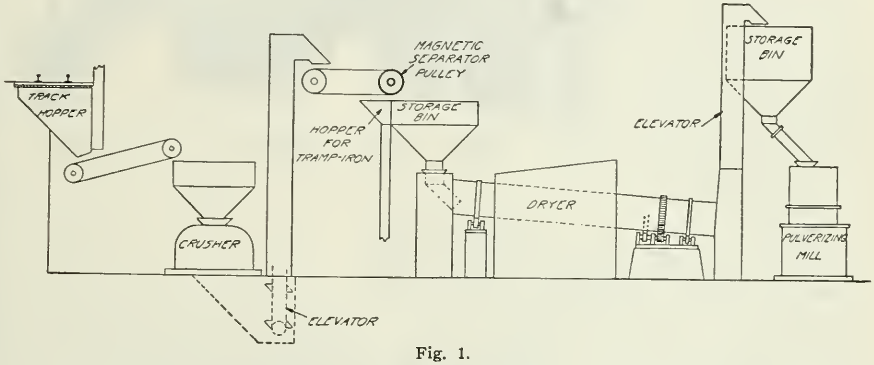


Fig. 1.

Magnetic pulleys are built in the following standard diameters: 12-inch, 15-inch, 18-inch, 24-inch, 30-inch and 36-inch for belts ranging from 16 inches to 60 inches in width. This range of sizes will take care of capacities up to 500 tons of coal per hour.

Magnetic Flux Distribution.

The shape of the electro magnets used in separator pulleys is somewhat different than the more familiar forms used in motors and other electrical apparatus, but the fundamental theory is the same, as is made clear from the following explanation and diagram.

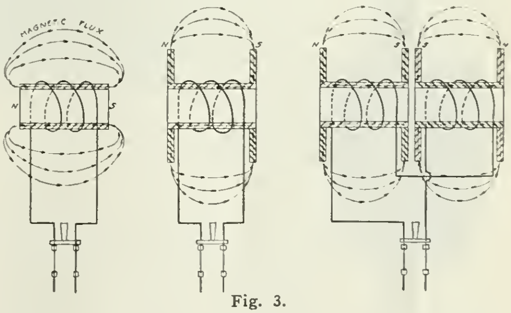


Fig. 3.

As a foundation consider the simple bar magnet shown in illustration 3 (A). A piece of steel rod or tube surrounded by a coiled wire carrying an electric current will form a magnet, one end being the north pole, and the other the south pole. The flux is indicated by arrows as leaving the north pole and entering the south pole. Part of the path traveled by the flux is through steel and part through air. A piece of iron or steel in the vicinity of either pole will be attracted by the magnet. Now consider that a steel disc is added to each end of the steel tube. Illustration (3B). The magnetic flux will follow the path of the steel in the discs, and flow from the periphery of one disc through the air, into the periphery of the other disc. The magnetic poles in the case are the cylindrical surfaces of the discs. A piece of iron in the flux stream will be attracted to one of the poles. Any number of these magnets can be added end to end, observing that a south pole is added to a south pole, and a north pole to a north pole. (Illustration 3C.) The latter illustration shows essentially the principle of the magnetic pulley.

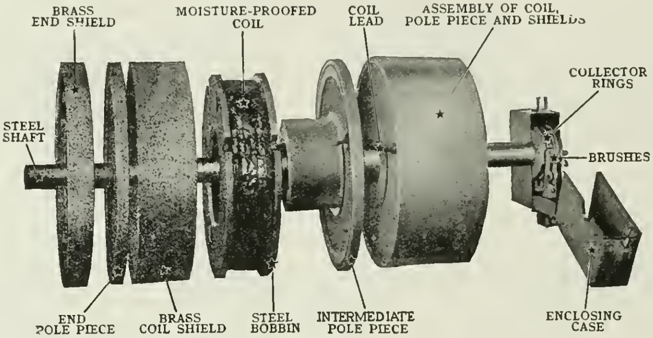


Fig. 4.

Details of Construction.

The construction of the Cutler-Hammer magnetic pulley is shown by the exploded view, illustration No. 4. The poles are steel discs keyed to the shaft. An electro magnetic winding is placed between adjacent poles. The magnetizing windings are wound on steel bobbins, making each coil a unit independent of the steel poles. The coil bobbins being made of steel form a useful part of the magnetic circuit. The coils are connected in series, and terminal leads are brought through a hole in the center of the shaft to a pair of collector rings located far enough beyond the edge of the pulley to permit the location of a bearing between the collector ring and the body of the pulley. The coils are impregnated with a moisture repelling and insulating compound by the vacuum process and the space between the coils and the shell is filled with the same compound, poured in the molten state during assembly. This provides protection from moisture, and assists conduction of heat from the coils to the radiating surfaces of the pulley. A tubular brass spacer, which also performs the function of a coil shield, is placed between each of the adjoining coils. After being assembled the pulley is turned and crowned.

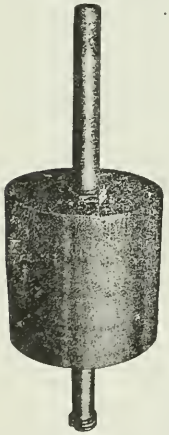


Fig. 5.

Mill Type Design.

It is expected that a magnetic pulley be as strong and reliable as other parts of the conveyor and pulverizing machinery. Careful and conservative coil design has made this possible. The unit coil construction is one detail the importance of which can hardly be overestimated. Wound on a heavy steel bobbin, the completed coil is a strong and solid unit, which lends itself to proper manipulation in the impregnating and assembling process. In the event of trouble with one of the coils, a new coil unit could be installed without making any changes in the poles or other parts of the pulley. This type of construction fulfills the demand of steel mills that all apparatus, electrical or mechanical, be designed to have all parts readily renewable.

Owing to the dusty atmosphere in which a magnetic pulley must operate, it should be entirely enclosed like a mill type motor. Only the cylindrical area and the ends of the pulley are figured upon as effective heat radiating surfaces. The pulley is designed not to overheat if it stands idle continuously. When operating the temperature is well below the safe limit. Another condition to be considered is that the temperature of the pulley should not injure a rubber belt, should the conveyor system be stopped for several hours, leaving one section of the belt in contact with the pulley. It is good practice, however, to electrically interlock the magnetic pulley with the motor driving the conveyor, so that the pulley is not energized when the motor is not running.

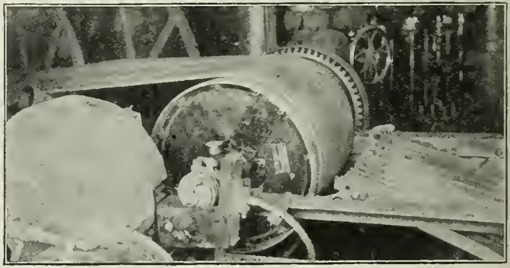


Fig. 6.

Importance of Correct Design.

In the design of magnetic pulleys there are two fundamental requirements to be observed:

a. Sufficient flux must be provided to attract and hold the largest piece of tramp iron carried by the coal.

b. The flux must penetrate space for a distance sufficient to bring under the influence of the pulley pieces of iron which have not worked to the face of the belt.

To meet these two conditions there must exist the correct ratio of steel in the poles, ampere turns in the magnetizing windings and spacing between poles. If the poles are too narrow, not enough flux can be carried to hold large pieces of iron. If they are too wide the flux density would become too low to be effective. A minimum distance of several inches must be maintained between poles, otherwise the greater part of the flux would cross the poles close to the face of the pulley and the flux penetration would not be obtained. Having the proper spacing between poles, the required number of ampere turns must be provided in the coils to force the flux through the path it must take in the air.

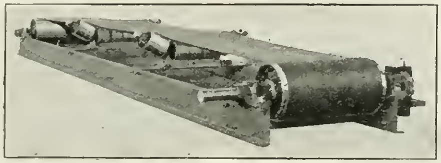


Fig. 7.

Belt Speed.

For the most satisfactory results the speed of the magnetic pulley should not exceed 38 rpm. This corresponds to 120 feet per minute belt speed for the 12-inch diameter pulley and proportionally higher speeds for larger diameter pulleys. At this speed the iron will be dropped well back of the pulley, leaving a sharp division point between the directions taken by the iron and the coal. Even at higher belt speeds, satisfactory separation has been effected, since the magnetic pulley will always deflect the iron from the path taken by the coal. Centrifugal action will, however, cause the iron to be carried ahead of the pulley so that a special arrangement of the coal hopper is required.

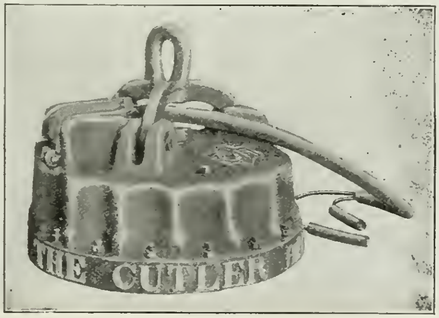


Fig. 8.

Strength of Magnetic Pulleys.

There is no single unit which will fully express the attractive force of a magnetic pulley. The sizes and shapes of the iron encountered in service are so variable that a statement of the pull which would be given to a specified piece of steel would not give a true idea of the performance under operating conditions. As an arbitrary figure, it is claimed that the pulley will remove pieces of iron weighing 50 pounds or less of any shape encountered. In practice it is rare that pieces of this size get as far as the pulley, being removed on the grizzly bars, usually located over the hopper which receives the incoming coal. Briefly stated, a magnetic pulley must be strong enough to remove all the iron when selected according to the published ratings.

Direct Current Required.

Direct current is required for excitation and 115, 230 or 500 volts is suitable. When A. C. only is available a small belted generator or motor generator set is used.

Short Conveyor Units.

Where it is desired to locate the pulley at a point where there is no belt conveyor, for example, between a bucket hoist and a storage bin, a short conveyor unit is installed. Illustration (7) shows a unit of this kind supplied by the magnetic pulley manufacturer. This unit consists of a code of 1,224 magnetic pulley with tail pulley and belt, mounted on a channel iron frame. The distance between pulleys is 16 feet. Units are supplied varying in length from 3 feet to 24 feet.

Stationary Magnets.

The layout of some plants, particularly old installations, makes it almost impossible to find a space for a separator pulley. In such cases a stationary magnet is used, suspended over the stream of coal. The familiar circular lifting magnet is best suited for this service on account of its great depth of flux penetration and rugged construction. Circular magnets are made in sizes from 24-inch to 62-inch diameter. It is not feasible to establish tables from which stationary magnets can be selected, as the surrounding conditions will seldom be the same in two cases. The surest procedure is to refer the question to the separator pulley manufacturer whose engineering department will study the requirements, and make a recommendation based on their experience.

A stationary magnet must be given periodical attention to remove any stray iron which has been removed. To guard against iron being dropped back onto the belt from the magnet in the event of current failure, a magnetic relay can be supplied in connection with the magnet, which will open the motor circuit, and stop the conveyor before the iron can reach the pulverizing mills.

Being automatic in operation, the magnetic pulley is recommended in preference to any other type of separator, and justifies any reasonable expense which may be required to change the machinery for accommodating the magnetic pulley.

Efficient Lubrication Reduces Power Waste

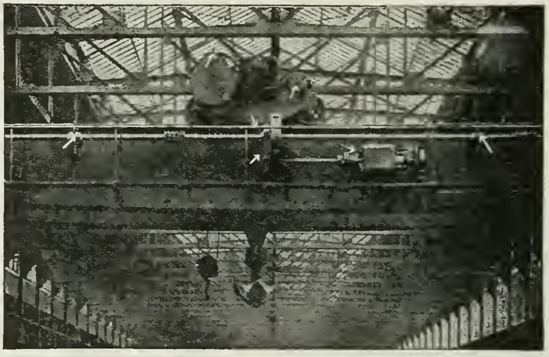
Friction Reduction of Even a Slight Percentage Through the Use of a Better Lubricant Will Offset the Extra Cost of the Lubricant in Decreased Fuel Consumption.

By H. A. BUZBY,
President and General Manager, Keystone Lubricating Co.

THE most careful investigation of all sources of expenditure is necessitated by the present-day manufacturing conditions. Because power is such an important and costly factor in the fabrication of steel, manufacturers must examine in careful detail all possible sources of inefficiency and loss and then take steps resulting in their elimination. Not only must the maximum amount of power possible be obtained from every pound of fuel consumed, but the highest percentage of power generated must be delivered actually to each machine in the plant. The achievement of these results is dependent upon the proper functioning of many factors. One of the most important of these is the elimination of friction.

A leading authority estimates that the average loss by friction is 50 per cent of the power developed. In the past much of this enormous loss has been considered unavoidable and its real significance has not been realized. So long as the plant is running without shutdown there was no serious cause for complaint.

Too little consideration has been given to the fact that even though bearings do not become so hot as to necessitate shutdown, the excessive friction may be causing extraordinary depreciation in machinery and often an even greater loss in decreased production. This condition is not due altogether to neglect, but is the natural result of long use of inferior lubricants, with a knowledge of their very definite limitations and the fallacious belief that not much better results could be obtained under any condition.


A crane lubricated with marked success by means of the Gravity Feed System of grease lubrication. Note arrows marking position of cups.

The study of efficiency methods and scientific management has led engineers to a real knowledge of the vital importance of proper lubrication and use of the most efficient lubricants. The use of oil is attended by many disadvantages, chief of which is its inclination to shirk its work. The fluidity which permits the oil to flow so readily into the bearing causes it also to run out as soon as the bearing surfaces are put in motion. So, that unless it receives constant attention, oil lubrication results in dry bearings, which in turn cause excessive friction, scored bearings and broken shafts, and not infrequently complete shutdown.

It is necessary to use a large quantity of oil to get a relatively small amount of lubrication. Oil lubrication is, therefore, expensive. The loss through wasted oil and cost of labor required in attention to lubrication is great, but the cost of power necessary to carry the friction load and the cost of repairs are very much greater.

As the demand for efficiency became more and more insistent it was apparent to all that a more efficient lubricant was necessary for use on the great majority of machinery. Once this need was apparent there was a general casting about for something with a greater lubricating quality and more advantages than oil. It was realized that a heavier-than-oil lubricant was essential to improved lubrication. This need resulted in the production of lubricating greases, many of which were originally (and still are) but little more than soft soap with a "filler," weight-making, non-lubricating, to give them body. The nature of this "filler" varies according to the theory of the maker. It may be wax, paraffin, resin, resinous oil, talc, clay, graphite or some other substance equally worthless for the lubrication of machinery, and in most cases positively injurious to the bearings to which it is applied. The failure of such mixtures to give efficient lubrication, and their tendency to increase rather than decrease bearing troubles, have naturally prejudiced many engineers against the use of grease.

The superior efficiency of a pure petroleum grease, scientifically manufactured from high-grade refined petroleum oils, from a formula by which a lubricating body of highest efficiency is obtained, under all working conditions the year round, has been so thoroughly demonstrated that it is now generally recognized by consulting and practical engineers as the ideal lubricant for practically all purposes.

The ideal lubricant contains no acid or metal-eating material; nor any resin, resinous oils, graphite, soapstone, wax, talc, powdered mica or other foreign substance which will scratch or pit the journal. Being purely petroleum it will not "gum up" a bearing. It is not affected by water, either salt or fresh or by steam, nor will it change or become rancid, but will improve with age, ever furnishing better lubrication at less cost than other lubricating compounds.

Crane Lubrication.

Conditions under which the large overhead cranes in use in various steel plants are compelled to operate require most consistent service. Many of these operate seven days a week, with the cranes in demand practically every hour of this time. The problem of reducing friction to the lowest possible point, so that bearings will need as little attention as possible becomes a vital point in obtaining the service desired. In the past attempt has been made to accomplish this result by the application of copious quantities of oil to all bearings, and if attention was all that was necessary, this should have accomplished all that could be desired. Unfortunately, however, very few, if any, oils are able to withstand the tremendous pressure to which the bearings of these cranes are subjected, and bearing and journal wear has been excessive, making untold overtime work necessary to keep the cranes in service.

Plants of importance have big work to be done and it must be done in a big way. Their reputations have been built on their efficiency and anything that will strengthen that efficiency is adopted regardless of cost. Large steel plants cannot afford to take chances on crane lubrication and every crane operator knows that the efficiency of a crane can never be greater than the efficiency of its lubricant.

Wire Cable Lubrication.

The cost of a good wire rope is far greater than the cost of a good lubricant. While superficial knowledge of the subject might lead to the conclusion that any cheap lubricant is good enough for cables, extensive investigation and expert opinions prove that only a lubricant of high quality and absolute dependability will insure satisfactory service.

To be really worth while the lubricant selected must percolate through the strands, thoroughly lubricating the cable from the surface to the core—preventing all foreign matter from entering between the strands, eliminating excessive friction, minimizing wear and excluding all moisture, not only making the cable a more efficient cable, but adding greatly to its life.

It must not be subject to alteration in density by the extreme variation of heat which the crane encounters in the performance of its duties. It must stand such tests as these:

At one of our large steel plants (Carbon Steel Company) in Pittsburgh, Pa., a sample of a well known cable grease was applied to the cable of a Shaw 150-ton auxiliary crane, October 7, 1918. This crane handled the hot metal from the furnace and poured it into large ingots, so that there was constant heat at all times on the cables. The crane inspector at that time upon examination, November 1, 1918, found the cable grease still on the cable and doing all that had been claimed for it. Being skeptical regarding this grease standing the heat and cold and seeing it after this period of time looking as good as on the day it was applied he put it to a severe test.

Three or four sacks of charcoal were placed in front of the furnace and the cables were lowered to have them in front and in direct contact, when the inspector opened the furnace door and the charcoal went up with a mass of flame around the cables.

Upon close inspection it was found that the cable grease was still clinging to the rope while the insulation of the electric wires were burnt off or badly scorched. This is a case of extreme heat. Now let us look at the opposite—extreme cold.

Williard C. Crofut operated a 20-ton shop crane and a 10-ton yard crane at a large steel plant in Ohio with the temperature at 10 degrees below zero. The density of the same brand of crane lubricant was in no way changed and the efficiency of both cranes was unusually satisfying to the representatives of the steel plant.

The Proper Application of the Right Lubricant.

It is now conceded by lubricating experts that grease must be made in different densities or consistencies to suit various conditions—heavy, viscous greases for heavy, slow-speed bearings and lighter, less viscous densities for lighter and higher-speed bearings.

The selection of the proper density for each purpose is of prime importance, but in addition, and in order to obtain the highest efficiency in service, it is necessary to see that all machinery is in perfect alignment, that the bearings be properly grooved so as to spread the grease over the entire surface of the bearings and that the proper means be used to apply the grease through grease cups, especially fitted to meet the various lubrication requirements.

Steel Mill Lubrication Problems

The Mills of the Weirton Steel Company, Which Were Recently Completed Are Equipped With Stream Feed Lubrication—Results Are Very Successful.

THE lubrication of steel mill equipment is receiving very much more attention by designing engineers and operators than it did a few years ago. In modern mills, all power units, and the mills themselves, are provided with stream feed lubrication. This results in very much better lubrication than was possible with the old intermittent hand feed method. This materially reduces friction, saves considerable labor, and what is more important, practically eliminates shutdowns caused from lubrication troubles such as worn-out and burnt-out bearings. It also materially reduces maintenance costs of the units being lubricated.

The new plant of the Weirton Steel Company, Weirton, West Virginia, which was designed and constructed under the direction of C. H. Hunt, chief engineer, is complete in every detail. A brief report of the facilities provided for lubricating this mill will be interesting to all readers of THE BLAST FURNACE AND STEEL PLANT.

Among the special equipment lubricated are three 7,500 kw General Electric Company's turbo-generators, and two Mesta cross compound blowing engines, and also the 42″ x 66″ x 60″ twin tandem compound reversing engine, manufactured by the United Engineering Company, Pittsburgh, Pa., is shown.

Fig. 1 is an interior view of this mill, and in the foreground is located an 18-inch continuous mill, manufactured by the Morgan Construction Company, Worcester, Mass. Further on in the mill may be seen a 21-inch Morgan mill and a 40-inch Blooming mill, manufactured by the Mesta Machine Company, Pittsburgh, Pa. The 18-inch and the 21-inch continuous Morgan mills are each direct connected to slow speed Westinghouse 4,000 hp motors. The engines and all the bearings on the rolls themselves, are being lubricated by the Bowser 6-F type oil filtering and circulating systems.

The receiving tank of this system is in an oil cellar at low enough elevation for the oil to drain back from the bearings by gravity. The filter tank of the system, which lubricates the 18-inch and the 21-inch Morgan mills is located in the motor room about midway between mills. The gravity tank is supported by platform constructed on the lower chords of the roof trusses.

In addition to lubricating the bearings on the Morgan mills, the pinions are also being lubricated by lubricating oils furnished from the same system. The oil is fed to the top pinion bearings, running from there to the lower pinion bearings and draining from the lower bearings into the housing. A constant level of oil is maintained in the pinion housing at an elevation so the pinion teeth will dip into it. This is a great improvement over the old method of lubricating these pinion housings, as it gets away entirely from all trouble caused by the mixture of the oils on the bearings with the grease on the pinions. A very high efficiency in lubrication is secured.

It is interesting to note that the outstanding features of the Bowser system of lubrication are the use of nature's process of purification by gravity and the "filter head" itself, which is unique in design. After the oil in the precipitating process is relieved of all water and a large percentage of its load of dirt, it enters the filter head or "filter section," as it is sometimes called.

This filter head is assembled in 12 sections, each containing pan, filter cloth and wire screen to hold cloth in place. These are securely fitted together in a single unit, as can be seen in the illustration. The oil enters through the valve in the central hub and flows upward and outward through the filter cloths. The filter cloths are self-cleaning, all dirt collecting in the pan beneath each cloth. This provision makes frequent cleaning unnecessary. The filtered oil flows outward through the openings in the edges of the filter discs and into the clean oil compartment of the tank. It is then pumped to the overhead gravity tank from which it flows by gravity to all the bearings to be lubricated. The used oil is then automatically returned to the filter again for purification.

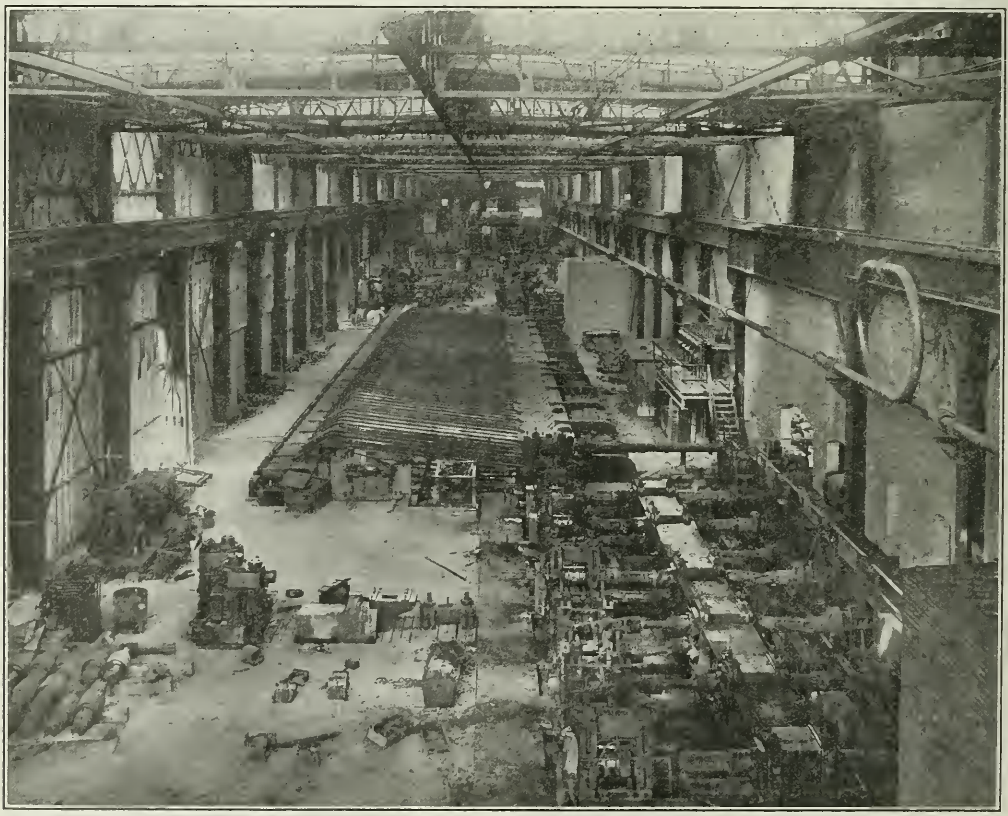


Fig. 1.

LETTERS TO THE EDITOR

To the Editor,
The Blast Furnace and Steel Plant,
108 Smithfield Street, Pittsburgh, Pa.

Dear Sir:

Referring to a paragraph in your issue of May, headed 'Slag as a Road Material in India," may I be permitted to elucidate the subject a little further.

As being connected with a large iron and steel plant in India, where for the first time an enormous quantity of slag was produced as a cumbersome by-product from the blast furnaces and where also for the first time a series of experiments were conducted with a view to utilizing this material and having had quite a few things to do with it, I believe some aspects of the use of this material will prove of interest to your readers.

The first blast furnaces of this particular works were blown at the end of 1911, and the slag was mainly used for recovering waste lands. The ladles, as they came out from the cast-house, were, in the initial stages, dumped into hollows and sinks to reclaim them and build them up to the level of the common ground. This method yet forms one of the main uses on the works site, where enormous areas to the north and east have been reclaimed or are in process of reclamation. Areas thus regained form wonderfully compact and rigid foundation for structures raised on them, but at the same time they make "some" work in subsequently excavating them for such constructions. A tremendous amount of labor, energy and money have to be expended, and where steam shovels and other labor-saving devices have been yet practically unknown, pick and shovels are the prevailing expedients and these last but a poor while on the hard unyielding mass. The process of excavation is unduly lengthened out by the slow and tedious method of breaking up the slag with hammer and crowbars. On cooling, the whole mass shrinks very appreciably, exerting at the same time a tremendous crushing force. A culvert meant to carry away waste water from the by-product plant was once embedded in several inches of thickness of hot-dumped slag. An obstruction to the flow was soon noticed, and it was decided to trace the delinquent spot. It was found at the junction of the slag with the culvert that three thicknesses of standard bricks of the arch of the latter had been literally crushed and disintegrated. The difficulty was obviated by covering up the arch with a thick layer of mud and stones.

A second use to which the slag is put on the works is by way of ballast on railroad tracks. The writer made extensive use of this medium, as compared to stone or quartz —of which an impure variety exists in abundant quantity— ballast slag was the cheapest available. Rs. 3/—or at the normal rate of exchange, equivalent to one dollar, was the average price paid for 100 cubic feet, while stone or quartz cost nearly double. And yet an ample margin was available for the middleman or contractor to profiteer at the expense of the poor stonebreakers who were cheated out of their just dues by an extravagantly low price of Re. one, or about thirty cents per 100 cubic feet, and by measurement with a rod that claimed to be three feet, when it ordinarily gave 50 inches on the tape. But profiteers are a kin the same all the world over. This ballast was as durable and serviceable as any other material used on tracks, and in many cases decidedly superior. When a homogeneous compact variety was selected, due to its heavy weight, bulk for bulk, its superiority over stone in preventing 'creep" on tracks was scarcely challenged. The right size for such purposes was ordinarily passed through a two-inch mesh.

Mixed with sand and cement, a better material could not be desired for concrete in foundations. Five baskets of slag (one-inch mesh), two of sand and one of cement with the requisite quantity of water formed an ideal combination. The binding mixture, penetrating the pores of the porous slag, formed on setting a very rigid, uniform mass. This form of use was extensively employed in the foundations of many buildings and shops in the plant, and in the Greater Extension scheme of constructions, it is exclusively the vogue. Then, again, on many a road in the steel town, after a variety of trials, it was found that the best results—so far as anything is finite—were obtained by first making a bed of either stone or slag metal and rolling it down with a steam roller. On top of this was spread a uniform layer, half to three-quarters of an inch deep, of half-inch mesh slag soaked in tar. Rolling and levelling it up, a very pleasing and perfect surface is presented, which, however, in the rainy season, has its own terrors for the rushing road-hogs. Here the proverbial slowness of the East evoke a just appreciation.

The quantity of tar needed for the macadam has to be carefully ascertained as any excess is apt to make things mighty uncomfortable and mussy in summer time, and has to be scrupulously avoided. A more pleasant appearance is usually imparted to the surface by a sparse sprinkling thereon of "soorkhi," a kind of reddish impervious clay that comes very handy near by.

A fifth use devised for this specious material was by hydrating it at the time it issues out of the furnace in a molten state. The hot liquid, coming in direct contact with water, swells into a highly spongy, porous, slightly yellowish white material, with a vigorous sizzling, and accompanied with an evolution of various gases—chief among them being H_2S— and an escape of great volumes of steam. The slag is then known as "granulated slag" and has a consistency of soft clay and is easily compressible. As an aggregate in mortar, it is unrivalled.

Experiments were conducted as early as 1914 with a view to finding out the suitability of powdered slag for brick making. The results obtained were eminently successful, but owing to the enormously prohibitive cost as compared with ordinary red bricks, the manufacture had to be abandoned. The ground slag was mixed with an ordinary binder, hard pressed into molds and subsequently dried. The difficulty experienced was in the drying process, which was extraordinarily long and slow. Even when the outer layers were perfectly dry, a greenish looking moist streak about half an inch thick persisted and extended through the middle and length of the brick of standard 9 x 5 x 3 dimensions, and was hard to get rid of. A compression test made on a 100-ton Bukton hydraulic press disclosed a pressure of 25½ tons per square inch before the edges began to get frayed, and at 27 the brick was more or less completely disintegrated.

M. HOMI.

3610 Fifth Avenue, Pittsburgh, Pa.

NEWS OF THE PLANTS

The Bethlehem Steel Company, Bethlehem, Pa., has preliminary plans under way for the erection of a number of additions to its plant at Steelton, near Harrisburg, Pa., to consist of new mills and auxiliary operating buildings, located on a tract adjacent to the present works. It is said that the proposed extensions with machinery will cost about $1,000,000. At its Baltimore, Md., plant, located in the Sparrows Point section, including the subsidiary organization, the Bethlehem Shipbuilding Company, preliminary expansion plans are being developed to represent a total investment of close to $25,000,000. The expansion will include extensions to the main steel works, as well as to the tin mills. At the first noted branch, facilities will be provided for the manufacture of a new line of commercial steel and iron products. The present ore-handling facilities will be enlarged, with plans for a large ore base at Sparrows Point, for handling raw materials from the company's properties in Cuba.

The Indianapolis Steel Products Company, New Palestine, Ind., has broken ground for the erection of its proposed new local plant for the manufacture of bar products. The plant will consist of a number of buildings, with full production equipment in the different departments. Walter Bledsoe is president; W. M. Lewis, superintendent of the Hoosier Rolling Mill, Terre Haute, Ind., will act as secretary, treasurer and general manager.

The Columbia Steel & Shafting Company, Pittsburgh, Pa., will defer for the time being the erection of its proposed new plant at Ambridge, Pa., plans for which have been prepared. The new works will consist of a number of one-story, brick and steel buildings of different sizes, and with machinery are estimated to cost in excess of $2,000,000. Hopkinson & Schaeffer, 500 Marion Building, Cleveland, Ohio, are architects for the new plant. I. C. Moon, company address, is plant engineer.

The Lorain Steel Company, Johnstown, Pa., is installing a new electric furnace at its plant, to be used for heat-treating railroad bolts and kindred products. The furnace will be of continuous pusher type, with capacity of about 14 tons of material daily.

The Wheeling Steel & Iron Company, Wheeling, W. Va., has resumed operations at its plant at Benwood, W. Va., giving employment to about 1,000 men. The plant has been closed for a number of weeks. Two furnaces are now in blast and other departments of the works will increase production, it is expected, at an early date.

The Reliance Steel Casting Company, Smallman street, Pittsburgh, Pa., will rebuild the portion of its plant recently destroyed by fire with a loss of about $25,000. The fire was caused by an explosion of gas in one of the drying ovens.

The Canadian Iron Foundries, Ltd., Fort William, Ont., has plans under way for the erection of a plant for the manufacture of wheels, high-grade iron castings, and other iron products, estimated to cost about $165,000 with machinery. The new plant will be operated as a subsidiary to the main works.

The Dominion Foundries & Steel, Ltd., Hamilton, Ont., has commenced the operation of its new 27-inch universal mill, recently installed. The large steel plates to be rolled will form a main feature of works production in the future. The new mill represents an investment of about $1,500,000; C. W. Sherman is president of the company.

The Standard Steel Works, 1722 Tracy street, Kansas City, Mo., has taken bids for the erection of a new plant at North Kansas City. It will comprise a one and two-story building, 120 x 225 feet, brick and steel, and will be equipped for general steel and iron production. It is estimated to cost about $75,000. Construction will be inaugurated at an early date.

The Buffalo Forge Company, 490 Broadway, Buffalo, N. Y., has plans under way for extensions and improvements in its plant to cost about $60,000. The present forge shop, 160 x 195 feet, will be remodeled and improved.

The Wheeling Steel Corporation, Wheeling, W. Va., has preliminary plans under way for the erection of a new plant in the vicinity of Portsmouth, Ohio. A number of one-story buildings will be constructed, forming a new wire and rod mill, with department equipped with finishing machinery for the manufacture of fencing, nails and other steel wire products. The estimated cost of the new plant is reported in excess of $200,000 with machinery. The project was approved at a recent meeting of the Board of Directors. The company at the present time has a number of improvements and extensions under way at its La Belle Iron Works plant at Steubenville, Ohio, for increased production and greater operating facility. Alexander Glass is chairman of the Board of Directors; Isaac M. Scott is president.

The Kansas City Foundry Company, Kansas City, Mo., has taken bids for the erection of an addition to its iron foundry, to be one-story, brick and steel, about 65 x 130 feet.

Joseph Stolz & Son, Inc., New York, N. Y., operating an iron and steel works at 841 East One Hundred and Thirty-sixth street, has awarded a building contract to the Comforti Construction Company, 324 East One Hundred and Fourteenth street, for the erection of a new one-story, brick and steel plant at Commerce avenue and One Hundred and Seventy-first street, estimated to cost about $35,000. Joseph Stolz is president.

The Charleston Bolt & Forging Co., Charleston, W. Va., recently organized with a capital of $200,000, has plans under way for the erection of a new local plant for the manufacture of machine bolts, carriage bolts, stove bolts, etc. The new plant will be one-story, brick, and is estimated to cost about $100,000 with machinery. Construction will be commenced at an early date. C. M. Dunnavant is president, and W. S. Stork, secretary and general manager.

The Florence Pipe & Foundry Company, Florence, N. J., has awarded a contract to the Austin Company, 217 Broadway, New York, for the erection of a one-story plant addition for increased production, to be 50 x 100 feet, and estimated to cost about $90,000 with machinery.

WITH THE EQUIPMENT MANUFACTURERS

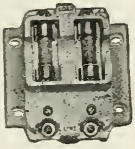
NEW SAFETY SWITCH MADE BY JOHNS-MANVILLE, INC.

Each year as the use of electricity has broadened its scope, there have come changes in apparatus and in methods of installing which are designed to make electrical installations so safe they are foolproof. No small part of this development has centered around the problem of enclosing the various parts of the circuit that carries electricity from the point where it may enter a building to the places where it will be used to operate motors, lamps or heating elements. One of the first steps in this direction was the use of conduit, and one of the most recent has been the development of enclosed switches.

Thee Three Simple Units.

(1) Box.

(2) Cover.



(3) Block.

As its contribution to this latest safety development, Johns-Manville, Inc., has devised a safety switch known as the Noark Allsafe Switch. This device has several new and advanced features, which are enumerated briefly below:

1. The Allsafe Switch is safe for the operator when switching and fusing.
2. The Allsafe Switch is safe when entirely open for inspection.
3. The Allsafe Switch may be locked against circuit closing operation.
4. The Allsafe Switch is designed to minimize arcing.
5. The Allsafe Switch has few parts and is constructed with the idea of insuring permanency.
6. The Allsafe Switch may be easily and safely installed.
7. The Allsafe Switch is comparatively small and light in weight; yet extremely rugged.

As may be observed from the accompanying illustrations, this switch embodies three simple units, namely, the box, the block and the cover.

The block on which the switch and the fuses are mounted is of new design. One of its principal features is that the fuses are mounted on the front of the porcelain block and the standard knife blade switch is on the back. When this block is mounted in the metal enclosing box, the fuses are on the outer side, while the switch is on the inner side. This arrangement makes the fuses accessible when the auxiliary cover of the switch is opened and places the switch blades out of reach of any except the persons authorized to open the main cover of the box. The design of this porcelain block has also been worked out so that proper spacing and well arranged barriers minimize destructive arcing, even under severe operating conditions.

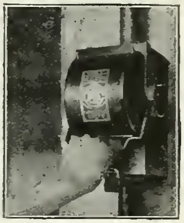
The words "line" and "load" appear in large plain letters on block at the terminals where the line wires and the load wire are to be connected. This makes it impossible for anyone who is competent to improperly connect the switch.

The switch blades are of rugged standard knife blade type and are individually hinged. They are arranged to be operated simultaneously by attaching each blade through a fibre coupling hook to a bail-like operating rod. This rod is in turn pivoted at two points in the rear of the box and projects through the side of the box where it engages the pressed metal handle. Moving the pressed steel handle, therefore, operates the switch blades.

In moving this handle to the "on" and "off" positions, it is desirable that the resulting movements of the switch blades be positive and snappy enough to eliminate unnecessary arcing at the switch contacts. For this reason the "on" movement of the blades is limited by positive stops; the "off" movement which breaks the circuit and at which time arcing is apt to be severe is accelerated by a simple spring. The switch clips, out of which the blades are pulled as the switches open, are at the lower rear end of the block. To make easy the inspection of these clips, and also the other switching parts, the lower end of the box is arranged to swing down on a hinge when it is unlocked. This provides a hinged inspection door.

The box in which the switch is enclosed is of 16 gauge sheet steel. The cover is of the same material. The compact design of the box may be judged from the fact that the 30 amp. size measures only 4 13/16 inches wide by 6 5/16 inches high, by 4 1/16 inches deep over all. Its small size permits it to be mounted on machine tools where it is most handy to the operator.

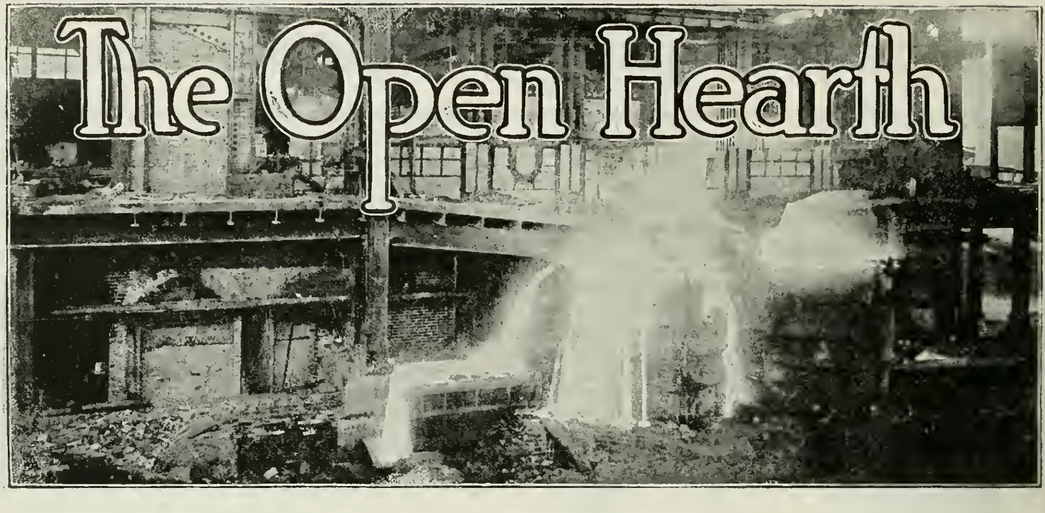
This switch is provided with two covers. The smaller auxiliary cover may be opened only when the handle of the switch is in the "off" position.



When the handle is down, the switch is open and the fuses are dead.

The operator may remove and install fuses with perfect safety. He cannot come in contact with any live parts.

Removal of the main cover by the properly authorized person for inspection of switch parts and live line contacts.



The Open Hearth

S. W. Palmer has been appointed superintendent of the Blairsville Iron Works, Blairsville, Pa. Mr. Palmer succeeds the late I. E. Edwards.

√ √

E. R. Swanson, who was formerly with the Duquesne Steel Foundry Company, Pittsburgh, Pa., is now president of the Keokuk Steel Castings Company, Keokuk, Ia.

√ √

W. H. Hegmann has resigned as general superintendent of the Atlas Crucible Steel Company, Dunkirk, N. Y. Mr. Hegmann held this position since 1915 and has made no announcement as to his future plans.

√ √

Joseph T. Dougherty, manager of the Mercer sheet works at Farell, Pa., of the American Sheet & Tin Plate Co., Pittsburgh, has resigned. W. L. Goodhue of Cleveland succeeds Mr. Dougherty.

√ √

D. T. Haddock resigned as general manager of the American Sheet & Tin Plate Co.'s works at Farrell, Pa., to become purchasing agent of the Baker-Vawter Company, Benton Harbor, Mich.

√ √

George M. Laughlin, Jr., grandson of the founders of the Jones & Laughlin Steel Co., Pittsburgh, has been elected vice president of the company, and F. M. Harbison has been made assistant treasurer.

√ √

A. L. Wurster, 1008 Drexel Building, Philadelphia, has been appointed to represent the Heppenstall Forge & Knife Co., Pittsburgh, for the sale of die blocks, forgings and shear knives, and N. & G. Taylor Co., Philadelphia, for forging steel, covering an eastern section running from Western New York to Central and Eastern Pennsylvania, Southern New Jersey, Delaware and Virginia.

√ √

Norton H. Van Sicklen has been elected president and general manager of the Reliance Wheel Company, Youngstown, Ohio, manufacturer of a steel double disc wheel. The company is preparing to increase production and has under option a manufacturing plant equipped with the necessary machinery. Mr. Van Sicklen formerly headed the Van Sicklen Spedometer Manufacturing Company, which was recently sold to the Stewart-Warner Corporation. He is known to the iron and steel trade as a former official of the American Steel & Wire Co. J. M. Crenan is director of sales of the Reliance Company.

√ √

Clyde E. Dickey recently resigned as general manager of the Hammond Steel Company, Inc., Syracuse, N. Y. Mr. Dickey is president of the Dickey Steel Company, Inc., 233 Broadway, N. Y., and will devote all of his time to this company in the future.

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Edward F. McGeehan, superintendent of the open-hearth department, and T. J. Driscoll, chief engineer, Pittsburgh Crucible Steel Company, Midland, Pa., have resigned.

√ √

Joseph G. Butler, Jr., vice president Brier Hill Steel Company, Youngstown, Ohio, has prepared a history of the Mahoning Valley and biographical sketches of many of its more important men and women, the work now being issued in three volumes. The introduction to the first volume was penned by President James A. Campbell of the Youngstown Sheet & Tube Co., long a personal friend of Mr. Butler, in which he points out that the latter's ability as an author is not the least of his talents. The work contains a complete history of the iron and steel industry of the valley, with which Mr. Butler has been actively identified for over half a century.

√ √

James E. McKenny has been appointed production manager of the Standard Spring Company, Cleveland, having recently retired from the organization of the Republic Rubber Corporation, Youngstown, Ohio, where he held a similar position. He was formerly superintendent of the National Works at Worcester, Mass., of the Wickwire Spencer Steel Corporation, before going to Youngstown.

√ √

John McKay, assistant superintendent of the McDonald mills, Carnegie Steel Company, Youngstown, Ohio, recently announced his retirement. He was superintendent of the Greenville, Pa., plant of the Carnegie Steel Company for 15 years prior to his transfer to the McDonald works. He will return to Greenville, Pa., where he has a large dairy and stock farm. His successor at McDonald has not yet been announced.

Some Pointers on By-Product Coke Oven Operations

THE MANUFACTURE OF ALCOHOL FROM COKE-OVEN GAS.

By C. F. Tidman.

Journal of Society of Chemical Industry.

The conversion of the ethylene present in coke-oven gas into alcohol and its derivatives was dealt with by my late chief, Mr. Ernest Bury, at a meeting of the Cleveland Institution of Engineers in December, 1919 (see J., 1920, 94A). The present paper contains a record of the work that has been carried on during the last twelve months on this subject. The suitability of alcohol as a fuel has already been established, and some figures which will be given in a later part of this paper will indicate how far these claims will hold when the power alcohol has been obtained synthetically from coke-oven gas.

Berthelot (1854) is generally credited with the discovery that ethylene could be fixed as theyl-sulphuric acid, which can then be hydrolyzed to alcohol, although Henry Hennell indicates in a paper communicated to the Royal Society in 1827 that he had identified sulphonvinic acid in quantity of sulphuric acid given him by Faraday, which had absorbed eighty times its volume of olefiant gas, or, in other words, 5 per cent of its weight of ethylene. In a paper published the following year he states that his sulphovinic acid decomposed into sulphuric acid and alcohol. Fritsche seems to have investigated in 1897, and more thoroughly in 1912, the application of this synthesis to industry, but when he found that 12 cubic metres of scrubbing surface was required per cubic metre of gas treated per minute he decided that the large scrubbing plant necessary would render the proposal unworkable. In the work we have conducted at Skinningrove we have decided that not only surface, but turbulent contact plays a part in deciding the speed with which ethylene will combine with sulphuric acid. While Fritsche seems to have worked along the lines of pressure, we have considered temperature and turbulence to be essential factors in successful and rapid absorption. Since the publication of Mr. Bury's work on this subject, a patent has been taken out by a Belgian firm, where success seems to have been attained by the use of catalysts such as vanadic and tungstic acids.

With very few data at our disposal the problem was attacked at Skinningrove under the direction of Messrs. Bury and Ollander. The first point was to determine the most suitabe temperature of absorption, and to this end absorptions were carried out at temperatures 160 degrees to 165 degrees, 95 degrees to 100 degrees, and 85 degrees to 90 degrees, respectively. The absorption apparatus consisted of two lead pots in series provided with stirring gear and containing 95 per cent rov, through which the coke-oven gas was passed in series. At 85 degrees to 90 degrees C. it was found that there was 0.25 per cent of carbon in the acid, showing that even at this temperature decomposition was occurring, while at 160 degrees to 165 degrees C. the acid used soon became gelatinous, while the exit gas contained a good deal of sulphur dioxide. Fig. 1 shows the progress of the absorption at temperatures below 85 degrees. The figures for these absorptions were obtained by using towers packed with fused silica as absorbers. From these data the best temperature of absorption was considered to be from 60 degrees to 80 degrees C. Four lead towers, each 4 feet 6 inches by 3 inches diameter, jacketed by a cylinder 5 inches in diameter, arranged in series, were packed with broken fused silica in such a way that the ratio of free space to packing space was as 2:5. The total capacity of the towers was 1 cubic foot, of which 5/7 cubic foot represented solid packing material. Sulphuric acid containing 95.4 per cent H_2SO_4 was fed down the towers by means of a siphon and carried to the top at intervals. During the first few experiments acid was fed down the tower continuously in the smallest continuous stream possible (at the rate of about 30 cc per minute), but later experiments showed that this was not necessary, since after flushing down the towers the acid flow could be stopped and the absorption continued without appreciable alteration for an hour. In one experiment, for example, the inlet gas contained 1.70 per cent of ethylene; after 5 minutes' absorption the outlet gas was found to contain 0.60 per cent of ethylene. The acid flow was then stopped and the percentages of ethylene in the exit gases were found to be as follows: 10 min., 0.60 per cent; 15 min., 0.64 per cent; 20 min., 0.64 per cent; 60 min., 0.66 per cent. A repeat experiment gave almost identical figures.

In the first absorption experiment carried out, desulphurized gas was passed through a bubbler containing 80 per cent sulphuric acid. The primary object of this scrubber was to remove moisture and any higher homologues of ethylene (propylene, butylene, etc.). In the gas produced under the conditions existing at Skinngrove, however, the presence of the higher homologues has not been observed, although doubtless these exist in small quantities. During the course of an experiment in which a gas richer in ethylene than coke-oven gas was used, viz., gas driven off from beechwood charcoal, which had been placed in the gas stream—a white, crystalline solid separated out on the 80 per cent acid; this was found to have the empirical formula C_5H_6, mp 126 degrees C., bp 250 degrees to 255 degrees C. With this solid was associated a second solid containing oxygen and of the probable empirical formula C_3H_8O; it had a very characteristic sweet taste, which persisted in the mouth for hours. Even using ordinary coke-oven gas a certain amount of solids settles out in the preliminary bubblers, but these are easily separated and can be discarded, although further investigation may prove them to be of value.

After the gas had left the scrubber containing 80 per cent acid it was passed through the experimental towers just referred to at the rate of 5 to 6 cubic feet per hour, and at the commencement the absorption was as high as 90 per cent of the ethylene entering the system. The experiment was made a continuous one and lasted 145 hours. The average speed of the first cubic foot of gas was 4.6 cubic feet per hour, while the average absorption of the ethylene was 90 per cent. The speed of the next 320 cubic feet was 4.8 cubic feet per hour, with an average absorption of 65 per cent. The total quantity of acid (95.4 per cent H_2SO_4) used was 3,000 cc. With a gas space in the towers of 2/7 cubic feet and a gas speed of 5.6 cubic feet an hour, the time of contact of gas with acid was thus 3.1 minutes, during which 90 per cent of the ethylene present was absorbed. These data multiplied up to plant size, where the daily carbonization is 800 tons, would suggest the use of nine scrubbing towers, each the size of the ordinary benzol scrubber, i. e., 10 feet diameter and 80 feet high. Of these nine towers practically the volume of six would be occupied by packing material, the function of which is to give surface and turbulence.

(Continued in July issue)

TRADE PUBLICATIONS

Geo. J. Hagan Company have issued Bulletin LF-102 entitled "Oil Burners and Combination Oil and Gas Burners for Industrial Furnace Application." This booklet is very complete in every detail and shows a number of cross sections of various burner settings.

"Blawforms for General Concrete Construction" is the title of a very attractive catalogue issued by the Blaw Knox Steel Company. The illustrations show the use of blawforms in practically every phase of the concrete industry. It is a very attractive book covering this subject.

The Root Company, Bristol, Conn., have recently issued a very attractive pamphlet entitled "Census Takers of Industry," which describes and illustrates the various uses of automatic counters in industries.

The Combustion Engineering Corporation have a very attractive booklet describing the "Coxe Stokers." It is very elaborately illustrated and contains general data and tests covering the use of these stokers.

The May issue of the Foundry World, published by the H. M. Lane Company of Detroit, contains several very interesting stories on modernizing foundries. One in particular, on the production at Timken-Detroit Axle Company's plant, being very interesting.

Richard Peters, Jr., manager of sales, Pulaski Iron Company, Philadelphia, is responsible for a very interesting booklet recently issued, entitled "Two Centuries of Iron Smelting in Pennsylvania." It is a story of the development of the iron industry of that state during the past two hundred years. The illustrations, which were very cleverly selected, show the various steps in the development of the Pennsylvania blast furnace from the Colonial hillside charcoal stack to the most modern iron maker of today.

The new P. & H. shovel attachment for use with standard P. & H. types 205 and 206 excavator-cranes is described in a pamphlet SX, just published by the Pawling & Harnischfeger Co. of Milwaukee. Illustrations of the shovel attachment in use are shown and the economy of being able to use either the 30-foot crane boom or the shovel boom is pointed out.

A new publication, "Armco in Pictures and Fact," has been issued by the American Rolling Mill Company. In this book they have followed the process of the manufacture of Armco ingot iron from the ore mine to the finished product in a very effective manner, both in illustrations and text.

The Northern Engineering Works have issued bulletin No. 508, illustrating their type "E" standard electric traveling crane. It is very complete in every detail.

"Blue Water Gas" is the subject of a pamphlet recently issued by the U. G. I. Contracting Company. This pamphlet covers the subject in every manner. It not only describes a blue water gas plant but also describes the use of the gas itself.

"Steel Plant Construction and Equipment" is the title of a very attractive booklet recently published by the W. W. Aindsay & Co., Inc. It is descriptive of the various installations which the company have recently made.

Refractories—The Refractories Manufacturers' Association have recently published the third edition of a booklet containing the names and addresses of all manufacturers of refractories in the United States. This 40-page booklet lists the various brands of refractories made by their respective manufacturers.

Electric Hoists — The Roeper Crane and Hoist Works, Reading, Pa., in their new catalog No. 50 gives specifications, dimensions and capacities of hook suspended type hoist, hoist with plain and geared I-beam trolley, hoists with motor driven trolley and cage operated monorail hoists.

Firebrick Cement—The Clinton Metallic Paint Company, Clinton, N. Y., in a four-page folder describe Clinton superheat firebrick cement, a refractory bonding material.

High Speed Steel — The Vanadium Alloy Steel Company, Latrobe, Pa., recently issued a 67-page booklet. In it they discuss the use, heat treatment, forging, annealing, hardening and tempering of high speed steel with particular reference to their Red Cut Superior Steel.

Some notes on grinding are also included with acknowledgment to the Norton Company. Several tables of weights compare carbon and high speed steel sections.

Pulverized Coal Equipment — The Fuller-Lehigh Company, Fullerton, Pa., have just issued bulletin No. 600. Pulverized coal plants for boilers are described and also designs showing burning equipment and furnaces for various types of coal are given.

Thermalloy—The Electro Alloy Company, Elyria, O., recently issued a catalog describing a high chromium alloy suitable for carbonizing pots and boxes. Further information relative to this alloy will be found on the page with the Equipment Manufacturers.

TRADE NOTES

The Mesta Machine Company announce the removal, on May 1, of their Chicago office from the temporary location in the Railway Exchange Building to permanent quarters in the McCormick Building, Michigan boulevard.

The Chicago office of the Uehling Instrument Company of New York, manufacturers of fuel saving equipment, was moved May 1 to the Great Northern Building, 20 West Jackson boulevard. Mr. Walter C. Lange has been appointed manager of this office.

The Champion Engineering Company, manufacturers of champion electric cranes, Kenton, Ohio, announce the opening of an engineering, service and sales headquarters at 326-327 Ferris Building, Columbus, Ohio. Mr. R. W. Valls, vice president of the company, is in charge of the Columbus headquarters as consulting engineer. Mr. Erwin B. Philips, who for some time has been works manager, will be in charge as general manager at the main office and works at Kenton, Ohio.

Mr. A. L. Wurster, 1008 Drexel Building, Philadelphia, has been appointed to represent the N. & G. Taylor Co. of Philadelphia for the sale of forging steel, and the Heppenstall Forge & Knife Co. of Pittsburgh for the sale of die blocks, forgings and shear knives, covering an eastern section running from Western New York State to Central and Eastern Pennsylvania, Southern New Jersey, Delaware and Virginia.

The board of directors of Arthur G. McKee & Co. recently selected Mr. Geo. S. Vail for the newly created position of general manager. Mr. Vail joins the board, which has been increased to five members.

The Electric Service Supplies Company, Philadelphia, will act as exclusive selling agent for the Peerless Equipment Company of Hanover, Pa., manufacturers of Peerless armature repair machinery and Segur coil winding tools. Heretofore Peerless armature tools were manufactured by the Manley Manufacturing Company, York, Pa., and Segur coil winding tools were manufactured by the Electrical Manufacturers Equipment Company, Chicago.

Mr. Charles A. Jayne, formerly president of the Architectural Service Corporation of Philadelphia, has joined the advertising and sales department of N. & G. Taylor Co., manufacturers of tin plate, Philadelphia.

COMING MEETINGS.

June 3-4—National Hardware Association of the United States, Metal Branch. Tenth annual meeting at the Cleveland hotel, Cleveland. George A. Fernley, 505 Arch street, Philadelphia, is secretary.

June 22-26 — American Drop Forge Association. Annual meeting will be held in Chicago. E. B. Horne, 6026 Helen avenue, Detroit, is secretary.

September 19-24 — American Society for Steel Treating. Annual meeting will be held in the Manufacturers' Building, State Fair Grounds, Indianapolis. W. H. Eiseman, 4600 Prospect avenue, Cleveland, O., is secretary.

The Blast Furnace and Steel Plant

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Electric Motor Drive for Traveling Cranes

A General Discussion of Electric Motor Drives for Cranes—The Question of Manual vs. Magnetic Control for Cranes Is Thoroughly Discussed.

By **GORDON FOX,**
Electrical Engineer, Freyn-Brassert & Co.

PART I.

THE electric motor is particularly adapted as a source of power for cranes, due to its small size and weight, its ready control, and the relative ease and efficiency with which electric power may be transmitted to the moving elements of the crane. The great majority of cranes are therefore electrically driven.

Cranes are built in a great variety of forms. The most common form is the overhead traveling crane. Gantry cranes find frequent application, particularly for outside work. The gantry crane, as represented by the ore and coal handling bridges, reaches very large proportions. Among the more special types may be mentioned soaking pit cranes, stripper cranes and chargers having rigid hoists and revolving types, such as locomotive and ship building cranes. This discussion will deal primarily with the more common types, the principles of which apply, with some modification, for all types.

Cranes may be classified also as to the nature of the service. A power house crane serves primarily for erecting and repair work. It makes heavy lifts at slow hook speeds, occasionally, and has long periods of rest. A mill or shop crane covers a variety of work, most of the lifts being below rating. The service is more or less intermittent. The speeds are intermediate. A material handling crane, such as a loading crane, yard crane, magnet handling crane or bucket handling crane, generally makes regularly repeated lifts, often near rated capacity. High speed is desirable or perhaps of first importance.

The function of the electric motor is to supply torque, power and motion to the crane elements. The crane elements are the hoisting mechanisms, the trolley traverse and the bridge travel. The hoist consists of one or more drums, driven through gearing from one or more motors. In the more common case one motor drives through two or three reductions to the drum. Ladle cranes are frequently equipped with two motors driving two drums, which are geared together. Bucket handling cranes usually carry two lines, a holding line and a closing line. These are carried on two drums which may be driven by individual motors. In some designs one motor is used, the closing line drum being geared directly to the motor, the holding line drum being driven through a clutch, which is air operated.

The hoisting speed of a crane depends upon the hoisting distance, the nature of the load and the service. A standby crane, such as a power house crane, may well have very low speeds because speed is not essential and precision is important. Moreover, low hoist speeds permit relatively small hoist motors. The investment in a standby crane may well be minimized by gearing for low speeds. Ladle cranes are operated at low speed as the hoisting distance is small and safety paramount. Heavy lifts may well be arranged for slow speeds, where permissible, as influencing the size of hoist motors and mechanisms, which are necessarily large and heavy. General service cranes are equipped for moderate speed hoisting. In this service particularly, the series motor characteristic is admirable in that the lighter work is done at higher speeds. Bucket and magnet cranes and material handling cranes in general are arranged for high speed hoisting. The extreme case is the ore and coal handling bridge which may hoist 100 feet or more, each trip. The following speeds are suggestive of existing practice:

Hoisting Speeds.

Type of Crane	Capacity	Hoisting Speed
Hand operated......	1 to 5 tons	1 ft. per min.
Standby............		10 to 25 ft. per min.
Ladle crane.........	100 to 150 tons	10 to 15 ft. per min.
Mill service.........	5 to 15 tons	25 to 60 ft. per min.
Mill service.........	20 to 50 tons	15 to 30 ft. per min.
Foundry............	5 tons	40 ft. per min
Foundry............	10 tons and above	12 to 25 ft. per min.
Auxiliary Hoists....		25 to 60 ft. per min
Skull cracker.......	5 to 15 tons	80 to 120 ft. per min.
Ore bridge..........	5 to 10 tons	200 to 600 ft. per min.

The work done by a crane hoist motor comprises the following items:

To hoist load against gravity.
To overcome friction of hoisting mechanism.
To accelerate load, impart kinetic energy.
To accelerate motor and mechanism.
To retard load in lowering.
To decelerate load in stopping.
To decelerate motor and mechanism in stopping.

We will investigate the relative import and magnitude of these elements of load. The work of hoisting may be expressed by the simple formulae.

$$T_h = \frac{W}{2\pi \ Ne}$$

$$HP = \frac{T_h \times 2\pi \times rpm}{33000} \text{ or } HP = \frac{WV}{33000 \times e}$$

T_h = motor torque to hoist load, foot-pounds.
W = weight of hook and load, pounds.
V = hoisting speed with load W, ft. per minute.
N = rev. of motor per foot hook travel = $\frac{rpm}{V}$
e = efficiency of gearing, decimal.

The friction losses in a crane hoist occur in the gearing and shaft and drum bearings, sheaves and cable bending. Each reduction introduces losses of 7 to 10 per cent. The hook, sheave and cable losses are about 3 to 5 per cent. Small, high speed cranes are usually the more efficient, having less mechanism. Their overall efficiency may reach 75 per cent whereas larger cranes will ordinarily have efficiencies between 60 and 70 per cent.

The following formulae apply to the acceleration of the hook and load of a crane.

$$T_a = \frac{\frac{W}{G} \times A}{2\pi \; N \; e}$$

$$HP = \frac{T_a \times 2\pi \; \frac{rpm}{2}}{33000} \text{ or } HP = \frac{\frac{W}{G} \times A \times \frac{V}{2}}{33000 \times e}$$

T_a = motor torque to accelerate load—foot-pounds.
G = acceleration due to gravity = 32.2.
V = velocity at end of acceleration period, ft. per min.
$\frac{V}{2}$ = average velocity during acceleration.
A = rate of acceleration—ft. per sec. per sec.

During the acceleration period, half the electrical input is consumed in resistance. The motor operates at reduced voltage and increased current. The heating of the motor is proportional to the current which, in turn is proportional to the input. Therefore, for determination of motor input and heating

$$HP \text{ (input)} = \frac{T_a \times 2\pi \; rpm}{33000}$$

or

$$HP \text{ (input)} = \frac{\frac{W}{G} \times a \times V}{33000 \times e.}$$

The rate of acceleration of crane hoists varies according to the service. The acceleration of an ordinary crane will not exceed 1 foot per second per second. A coal or ore bridge will accelerate at 1 to 5 feet per sec. per sec., 2 to 2.5 ft. per sec. per sec. being usual average figures.

A comparison of the formulae for hoisting and accelerating torques gives the following:

$$\frac{T_h}{T_a} = \frac{W}{\frac{W}{G} \times a}$$

Let $a = 2$ ft. per sec. per sec.
$T_h = 16 \; T_a$

It will thus be seen that the accelerating torque is a relatively small item, in hoisting except at high speeds, 600 ft. per min. and above. The torque and power necessary to accelerate the motor armature, brake wheel and revolving mechanism, may be expressed by the formulae:

$$T_m = \frac{W_r{}^2 \times rpm \times 2\pi}{G \times 60 \times t}$$

$$HP \text{ (input)} = \frac{W_r{}^2 \times rpm^2}{1613000 \; t}$$

T_{m2} = motor torque to accelerate motor and parts number feet.
W_r = moment of inertia of revolving parts at motor shaft number feet².
t = time to accelerate to rpm = $\frac{V}{a}$, sec.

In the ordinary case, the inertia of armature and hoisting mechanism proves to be a relatively small item.

The conditions in lowering depend upon the loading and upon the type of motor and control. As direct current motors with dynamic braking control are most common, they are selected for discussion. To lower a light hook the motor must exert power driving the hook downwards, since the weight of the hook is not sufficient to overcome the friction of the hoisting gear. At some fractional load, perhaps 5 to 15 per cent of rating, the load is sufficient to overcome hoist gear friction. The motor armature then merely floats on the line, taking little or no current. With higher loads the motor restrains the load, which is overhauling. Moreover, the armature current and the field current have different values, in lowering. It is therefore difficult to definitely evaluate the heating effect of the motor in lowering. The following approximations may be used:

To lower light hook:

$$HP = \frac{W \times V \times .10}{33000}$$

Where W = rated load—pounds.
V = lowering speed, feet per minute.

To lower an overhauling load:

$$HP = \frac{W \times V \times e}{33000}$$

Where W = weight of load—pounds.
V = lowering speed—feet per minute.
e = efficiency of hoisting gear, using same values as for hoisting.

In the case of a two motor, bucket handling hoist, the hoisting load may be considered as equally divided between motors. The closing load depends upon the bucket and condition of material but may be taken as half the hoisting load. The load in lowering may be taken as occurring 80 per cent on the holding line and 20 per cent on the closing line.

The determination of the size of the hoist motor for a crane is based upon its ability to develop safely sufficient torque to lift and accelerate the heaviest load which the crane may be expected to handle, together with heat dissipating ability to enable it to withstand successfully the service which will prevail. These two considerations may differ materially. Some cranes, such as bucket handling and yard cranes, may be expected to handle rated load regularly. For such cranes, considerations of heating will determine the motor selection. General service cranes handle an average load of about 25 per cent rating. Inasmuch as cranes are designed with some overload capacity, 25 to 50 per cent, the motor should have sufficient torque to handle such a load. It will then be capable of handling the normal load with ease.

The following method for hoist motor size selection is suggested. Determine the hp required for hoisting and accelerating, by the formulae given above. In determining this hp, use load and speed values corresponding to the crane capacity rating. For standby cranes the hp thus found may be made equal to the 15 minute hp rating of the motor selected. For general service cranes the hp rating as determined above should correspond to the 30 minute hp rating of the motor selected. For cranes operating upon regular cycles a motor should be selected whose 60 minute rating, or longer time rating for severe service, covers the hp requirements. For cranes of the latter class, a check on motor heating, as later described, is desirable.

The motor size having been determined, at least tentatively. The gear ratio between winding drum and motor may be found by the formula:

$$N = \frac{\text{rpm}}{V}$$

N = motor revolutions per foot hoist travel.

Where rpm = motor speed corresponding to hoisting hp with capacity load.

V = hoisting speed with capacity load, feet per minute.

Knowing N, the sheave arrangement and drum diameter, the gear reductions are determined. In selecting the hoisting speed and gear ratio for a crane equipped with a direct current series motor, the fact should be borne in mind that the crane will hoist the empty hook at 200 to 25 per cent rated speed. The average load for a general service crane is about 25 per cent capacity. The corresponding speed is 150 to 175 per cent rated speed with capacity load. The speed should be selected as most suitable for the average load, the rated speed being correspondingly lower.

The motor size and gear ratio being selected, it may be well, particularly in the case of the general service and standby cranes, to check the torque demanded to hoist the heaviest probable overload, to see that the motor will develop this torque with a safe overload current value.

In the case of the continuous duty loading crane, the motor selected should be checked as to heating. The best method for doing this is by comparing losses with heat dissipating ability. The method may best be illustrated by a typical case, involving the hoist motor of a bucket handling crane. The hp for the various movements have been determined as above and the time of each movement determined by comparison of distance and speed or by means of time distance curves based on velocity and acceleration values selected. A table may then be prepared tabulating the losses about as follows:

Seconds	Action	Output hp	Watts Loss From Curve	Watts Loss × Seconds
6	Close bucket ...	40	4,200	25,200
10	Hoist	80	10,400	104,000
3	Open bucket ...	30	3,500	10,650
10	Lower	45	4,650	46,500
16	Rest	0	0	
45				186,350

The values of watts loss corresponding to hp output are taken from motor manufacturer's curves. The total running time is 6 + 10 + 3 + 10 = 29 seconds. The average watts loss while running is $\frac{186350}{29} = 6420$. From the motor curves it may be found that 6420 watts loss per second while running will not heat the motor above 75 degrees centigrate rise provided the running time is not more than 65 per cent of the total time. In the above case the running time is $\frac{29}{45} \times 100$ or 64 per cent of the time. Therefore the motor will not overheat under this duty, continuously repeated.

In the above discussion, a series wound direct current motor with dynamic braking control was considered. Dynamic braking control is now used almost universally on direct current equipped cranes. However, for alternating current cranes, the practice varies. In the majority of cranes mechanical load brakes are supplied. In lowering, the motor drives downward against the retarding effort of the load brake. In some ac cranes of special types, the lowering is done by friction brakes, independent of the motor. In some of the larger installations such as coal unloading rigs, alternating current motors are equipped to give dynamic braking in lowering. This is accomplished by applying direct current to the primary windings and adjusting the rotor resistance to control the braking effect. The necessary low direct voltage is obtained from a small motor generator set or by a generator connected to the hoist motor directly. This scheme is not practical for general use. There has been recently developed a socalled "solenoid load brake," having two solenoids. One of these is connected across primary voltage and is energized only while hoisting. At standstill or when lowering this solenoid is released, causing a small braking torque. The second solenoid is connected across the rotor of the motor. When this solenoid is de-energized, as at standstill, full braking torque is obtained. When this solenoid is energized; the braking torque is relieved in proportion. As this solenoid is connected across the rotor voltage, the higher the speed in lowering, the less the slip and the lower the rotor voltage, hence the greater the braking torque. The brake thus automatically adapts its effort toward controlling the speed. This type of brake will probably find more extensive use on ac equipped cranes in the future.

The holding brakes for any crane should, in general, be capable of exerting a torque equal to 125 per cent rated motor torque. The brake will then hold a somewhat higher load due to friction of the hoisting gear. Cranes not equipped with mechanical load brakes, in sizes of about 20 tons and above, are advisedly equipped with a second holding brake. The main holding brake is applied to the motor shaft, the second brake to the first reduction shaft. The brake on the motor shaft should be a shoe type or disc type brake, to avoid side thrust on the armature shaft. The second brake is usually a band brake arranged for maximum effort in the down direction.

The trolley traversing or "racking" drive of the overhead traveling or gantry crane ordinarily comprises one motor, driving through two or more gear reduction to the axle shaft of two of the four trolley wheels. On man trolleys of coal and ore bridges the trolley drive usually takes the form of two or more motors, each driving a pair of wheels through a single gear reduction. This gives good tractive effort by driving as many wheels as possible and is favorable to the uniform distribution of trolley weight.

The traversing speed of a trolley depends on the capacity, length of span and nature of service. On a large ladle crane the trolley speed, with load is usually about 75 feet per minute. General service cranes have traverse speeds ranging from 125 to 200 feet per minute, the higher speeds being for such as loading cranes, where speed is desirable. Man trolleys for coal and ore bridges usually range from 600 to 1000 feet per minute, sometimes higher. The figures given above refer to load conditions. Without load the speeds may be 50 to 100 per cent higher, depending on relative weight of trolley and load and motor characteristics.

The work required of the trolley traverse motor, or motors, comprises the following elements:

To overcome journal and track friction.
To overcome friction of drive mechanism.
To accelerate trolley and load.
To accelerate motor armature and revolving mechanism

The so-called "friction load" is made up of rolling friction, flange friction and journal friction at the axles and bearing and gear friction in the drive mechanism. Rolling friction depends upon the diameter of wheels, condition of track, whether all wheels are true circumference, etc. Flange friction depends on wheel alignment, track alignment and wheel end play. Because of these many variables the power for driving a trolley or bridge may vary over rather wide limits. The following formula is sometimes used to determine axle and rolling friction or so-called friction draw bar pull.

$$DB = K \frac{(.10_r + .002)\ W}{R \times e}$$

Where DB = friction draw bar pull or combined traction of driving wheels—pounds.
r = radius of wheel axle—inches.
W = total weight, trolley and load—pounds.
R = wheel radius—inches.
e = efficiency of reduction shafting and gearing, usually about 80 per cent for trolley drive.
K = a multipher—1¼ to 1½, to cover flange friction or other uncertainties.

Inasmuch as trolley travel friction is susceptible to a number of somewhat indefinite variables, it is best, perhaps, to use values determined from practice. It is found that friction draw bar pull for a trolley is usually within the range of 15 to 30 pounds per ton of load, depending upon size of wheels and axles and drive arrangement. Rolling friction increases with the speed but, within the limits of speed of cranes or bridge trolleys, this variation is of less magnitude than other variables, so that a fixed value of friction draw bar may well be used.

Having determined the draw bar pull, the hp necessary to drive the trolley at free running speed may be found from the simple formula:

$$HP = \frac{D_f \times W \times V}{33000 \times 2000}$$

Where D_f = friction draw bar, pounds per ton.
W = weight of trolley and load—pounds.
V = free running speed—feet per minute.

The force or draw bar pull necessary to accelerate a crane trolley may be determined from the simple product of mass times acceleration. Thus

$$D_a = \frac{2000 \times a}{G}$$

Where D_a = draw bar for acceleration—pounds per ton
a = ratio of acceleration—feet per second per second.
G = 32.2

The rate of acceleration of crane trolleys varies within a range of ¾ to 3 feet per second per second. A rate of 2 feet per second per second is about as rapid as feasible without excessive swing of suspended load, or discomfort to the operator. This value should be used for fast cranes and man trolleys and where the trolley must spot over a swinging hook. A lower rate is advisable for heavy loads and trolleys with rigidly suspended loads. A low rate of acceleration may be used on standby cranes in order to reduce motor size. A trolley having but one-fourth of the wheels driven cannot be accelerated faster than 2 feet per second per second without wheel slippage.

Using the value of 2 feet per second in the above formula, the draw bar pull for acceleration becomes 125 pounds per ton. It may be seen that this draw bar pull for acceleration is several times the 15 to 30 pounds per ton of friction draw bar. It is thus evident that a motor producing the above acceleration must exert, during the starting period, much higher torque than during free running periods. Since free running load must be considerably less than rated load, acceleration will continue for sometime after all resistance is cut out and the motor is across the line.

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(To be continued)

250-TON SHIP CRANE FOR THE U. S. NAVY.

A contract has recently been awarded for the construction of a 25-ton revolving crane to be mounted on the hull of the U. S. battleship "Kearsarge." This is stated to be the largest seagoing crane under consideration, and it is the intention to transport the ship. with its crane, to whatever port requires its services. The "Kearsarge," launched in 1898, is 375 feet o.a. by 72 feet beam, with 23 feet 6 inch draught, on 11,520 tons displacement. The guns, turrets and armour will be removed and bulges added, giving a total beam on w.l. of 92 feet, for increased stability. The 250-ton crane falls consist of two 125-ton blocks on the jib, and an equalizer block at the hook. A 40-ton auxiliary block is also suspended from a traveling trolley on the jib.

The jib is luffed by the usual arrangement of vertical screws with nuts on the elbow of the jib. The range of these screws permits the jib to be luffed to all working positions, and also to be lowered into a position, approximately horizontal when the jib outer end rests in a latticework cradle at the after-end of the vessel, and is ready for sea. The whole of the working arrangements of the crane are described in detail, and the operating speeds for all the functions of the crane are given. Identical motors, eight in all, mill type, series wound, 110 hp, are used for the various operations.—The Technical Review.

OVEN ACCIDENTS FEWER.

According to the bureau of mines accidents at coke ovens in the United States in 1920 caused the death of 49 employes and the injury of 3,415 others, compared with 53 deaths and 4,031 injured in 1919. In 1920 the coke industry employed 28,139 persons, each employe averaging 319 working days in the year.

Casting Large Pipe Fittings

Eastern Shop Makes 96-Inch Elbows for 10,000 K. W. Installation for Steel Plant, In Dry Sand Mould — Interesting and Successful Methods Produced High Class Castings.

By JAMES J. ZIMMERMAN,
Assistant Superintendent, Scott Foundry, Reading Iron Co.

THE Scott Foundry, now the mechanical department of the Reading Iron Company in Reading, Pa., is one of the oldest foundry and machine companies in the east. It's history covers a period of progress dating from early in the eighteen hundreds. It's present product, in addition to the maintenance of the above company's mills and plants, covers the manufacture of all classes of heavy machinery, especially rolling and sugar mills and cotton baling presses. The foundry, for it is in this our readers will be most interested, is similar to any other of modern type. It differs very substantially, however, for in addition to operating two cupolas, it operates three air furnaces, in which rolls and special high grade castings, which require high strength and corresponding physical properties, are made. In addition to making iron, steel castings are produced. The steel is made in a tropenas converter. Pipe balls are cast from special manganese steel made in a crucible furnace.

Recently this Company contracted for the furnishing of a number of large pipe fittings for the 96-inch exhaust line of a 10,000 kw installation, which consisted of a number of special fittings, reducers and elbows. It is the casting of the 96-inch elbows that the writer wishes to describe in this article.

The elbows, as shown in Fig. 1, were made from cast iron with walls 1½ inches thick, and weighed 27,600 pounds each in the rough. The flanges were finished 2¼ inches in thickness by 108 inches in diameter. A 24-inch outlet can be seen and also four suspension lugs.

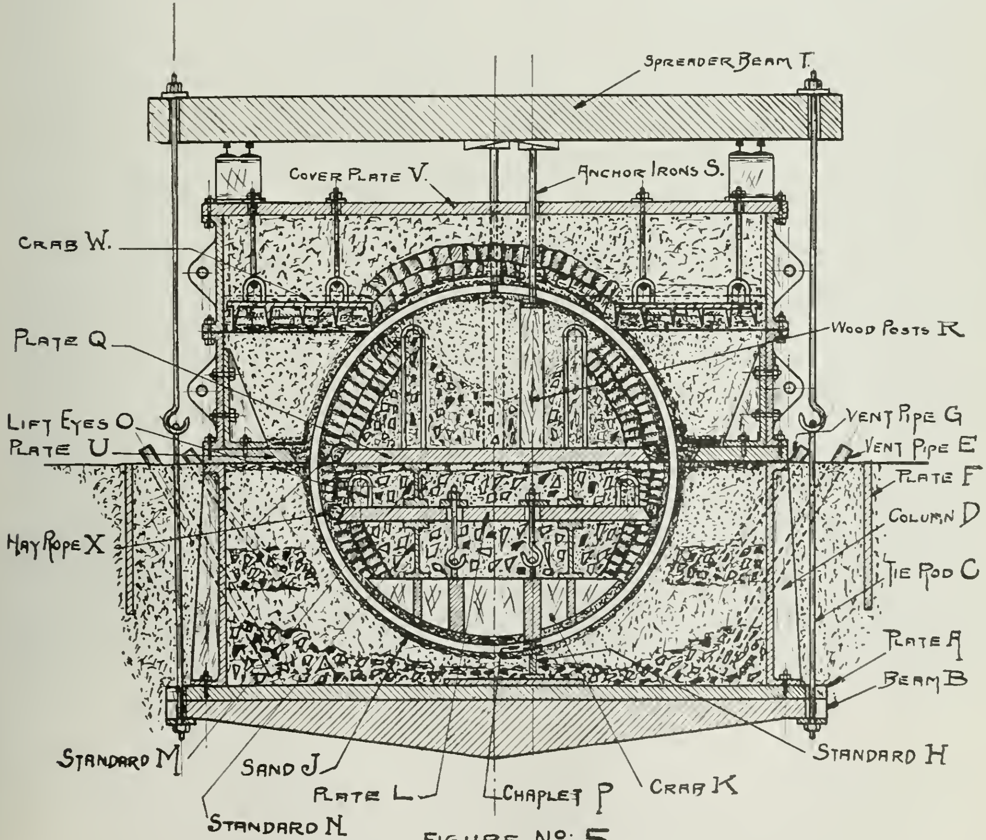
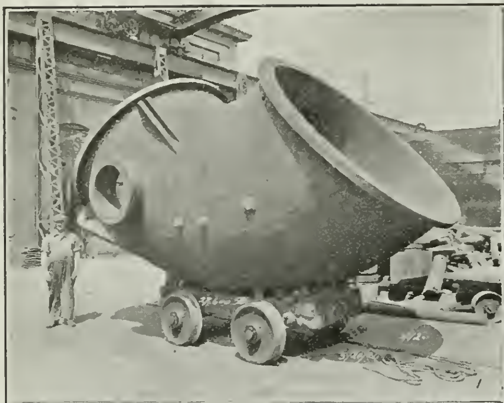


FIGURE No. 5.
SHOWING METHOD OF THE CONSTRUCTION OF THE MOULD.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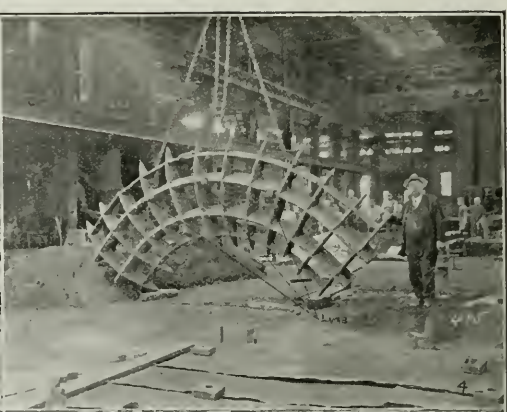
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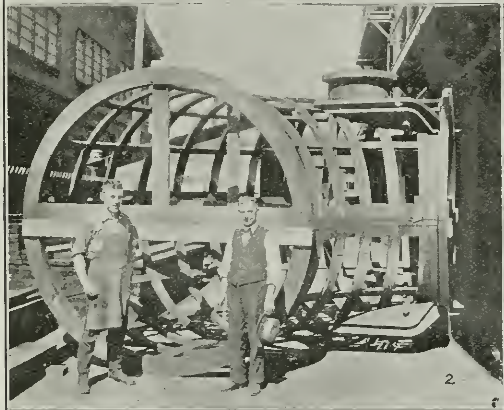
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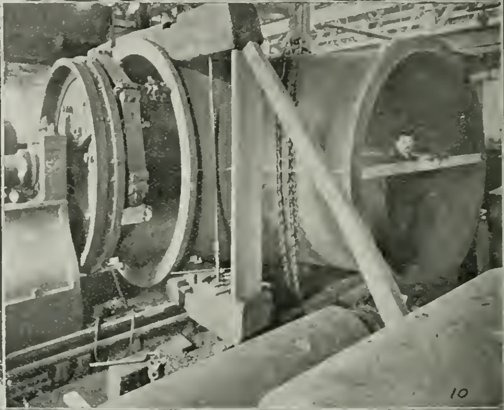
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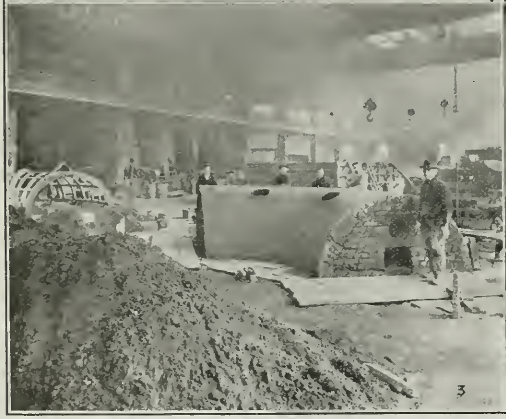
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The radius on the neutral axis is 94-1/16 inches.

Patterns.

A skeleton pattern, as shown in Fig. 2, was used for making both the core and mould. It is not necessary to say anything especial about this pattern except that particular attention was paid to accuracy. It was split in halves, as shown in the background of Fig. 3, and was used as such, half for the cope and top half of the core, and half for the drag and bottom half of the core. The suspension lugs and side outlet nozzle were separate patterns, and were pinned on to the main pattern, in order to withdraw them separately from the cope and drag. The flange on the outlet nozzle was made in sections, in order to permit its being picked from the drag. The slot in the suspension lugs was cored and necessarily required a core box, as did the core for the nozzle.

The crab, as shown in Fig. 4, was made from a pattern, while all other fixtures, such as plates, flask sides, etc., were open sand castings, and consequently required no patterns.

Building up Mould.

In constructing the mould, the procedure was as follows:

First—the drag
Second—the bottom half of core
Third—the top half of core
Fourth—the bottom section of cope
Fifth—the top section of cope.

This is illustrated best by sectional view Fig 5. After the hole in the floor was dug to a depth of about 7 feet, the plate (A), in two sections, which covered the entire bottom of the mould, with six beams under it, through which the 1¾-inch tie rods (C) ran, was leveled up. Next the standards or cope supporting columns (D), of which there were six on each side of the mould, were placed in position and the initial part of the drag was begun by spreading a bed of cinders over the entire bottom and placing the deep vent pipes (E). These deep vent pipes were four inches in diameter, and numbered three on each side and two on each end of the mould. Next a temporary shoring, approximating the outside diameter of the pattern, was placed in the drag, in the position which would later be occupied by the pattern, and the drag filled in with sand and cinder and rammed up. This included the placing of the 3-inch upper vent pipes (G), of which there were three on each side and two on the ends, as well as the reinforcing or shoring plates (F), also the setting of the chaplet supporting standards (H) of which there were three placed 10 inches away from the center line of the elbow, as shown in Fig. 6.

Next the temporary shoring was torn away, and a layer of facing sand, denoted by letter (J), was spread and upon it the bottom half of the skeleton pattern with nozzle and two suspension lugs on same was placed, rammed up and swept off. Upon this a layer of paper was placed, and work begun on the construction of the bottom half of the core. This part of the work was begun by placing the crab (K) so that the three lugs, noted on Fig. 4, came directly over the chaplet standard (H). The chaplets then came between two metal surfaces, and in this way helped support the heavy core and maintained an even space for metal which formed the elbow. Between the mould and the crab a layer of facing sand was spread, and upon it the entire bottom half of the core was constructed of brick, loam and cinder, as shown together with the cast iron plate (L), standards (M) and (N), hook bolts and lifting eyes (O). Note that so far as we have gone, all the weight of the core was supported on the metal plate (A) through the standard (H), chaplet (P), crab (K), standard (N) and plate (L), and that no weight was thrown on the sand mould except on the core prints, which are shown in Figs. 6 and 7, which were the same diameter as the core itself and extended beyond the faces of the flanges into the cope and drag on each end for a distance of 30 inches. Vent pipes not shown were run from each end of this lower section of the core to the floor line.

Next the top half of the core was built up by placing the cast iron plate (Q) with lifting eyes in same directly on the lower half of the core, and building up with brick, loam, cinder and facing sand. Note the hay rope (X) at sides of plate (Q) and plate (L) in lower half, to permit contraction of the elbow after pouring without fracture or harm. When this top half approximated the required size, the top half of the skeleton pattern was placed over it and the core was swept off and finished to the outside diameter of the pattern. Note at this point the 6-inch square wooden anchor posts (R) with iron plates upon them with the anchor iron (S) in turn upon them. These anchors were run up to the spreader beams (T), of which there were six and through which the rods (C) passed on down to the bottom beams (B) thus tying the entire mould together. These anchors were forced down tight by means of wedges, thus preventing the core from swinging upwards and assisting the core prints in keeping the entire core down. In this way any movement of the core was prevented, and the required thickness of the walls of the elbow obtained without distortion. The object of the wooden posts was that they charred from the heat of the metal and crushed. Hence there was no chance of the elbow cracking on cooling, due to contraction or shrinkage. You will note that both halves of the core are held down solid, the bottom half by the top half, and the top half as follows, beginning with spreader beams (T) through the wedges, then the anchor irons (S) on through the plates and wooden posts (R) to the plate (Q), which rests on the bottom half of the core, with the core prints of course taking their portion of the work. These anchors were ten in number, four of which were on the center line of the elbow, and six on a line 10 inches off center, all as shown in Fig. 7. The finished core may be seen in Fig. 3.

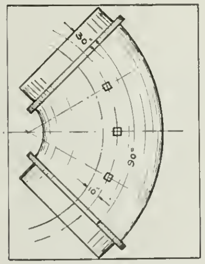

Figure No 6.
Showing Location Of Chaplets.

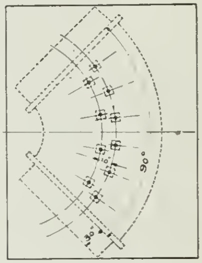

Figure No 7
Showing Location Of Anchor-Rods

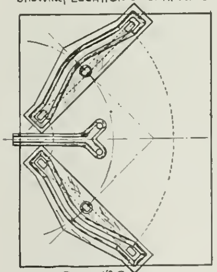
Figure No 8.
Showing Gates Runners Risers Etc.

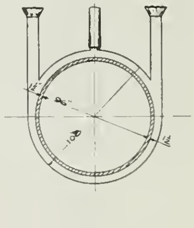
Figure No 9.
Showing Location Of Gates And Riser

A glance will show how the cope, which rested on a solid cast iron plate (U), and which was covered by a cover plate (V), which was in two sections, was constructed of sand, loam and brick but no cinder. The parting of the two sections of the cope was made on a line where the crabs (W) are shown suspended from the top cover plate. Next the mould was torn apart and finished after the pattern, including lugs and outlet pieces, was removed. After finishing and slicking the faces, the cope and cores were taken to large core ovens for drying, while charcoal fires were built in the drag. You may therefore see that the elbows were dry sand castings.

After drying, the cores, including those for the outlet nozzle and suspension lugs, were set and the entire mould was assembled, and all rigging such as tie-rods, etc. tightened securely. The risers, runners, pouring basins, gates and pop gates or run-overs were then formed, as shown in Figs. 8 and 9. Next the entire mould was weighted down, as shown in Fig 11, with a number of heavy chills, etc., which approximated 140 tons, computed, of course, on the theory that a body immersed in a liquid is buoyed upwards by a force equal to the weight of the liquid displaced.

Next came the pouring, as can be seen in Fig. 11, which was done simultaneously from both ends of the mould and through four gates (two on each flange), as shown in Fig 9. Immediately after pouring and settling, the weights were removed and as much of the mould as possible was torn down, and the sand portion in the top half of the core dug out, so as to relieve strains from contraction, which might have caused checking or cracking of the elbow. After four days the elbow was dug out, and cleaned and transferred to the machine shop for machining. Fig. 1 shows it on its way to the machine shop, and Fig. 10 shows one of its mates without nozzle or suspension lugs being machined in a nine foot engine lathe.

Flue Dust Production and Consumption

The Reduction In Amount of Flue Dust Produced and the Recovery and Use of All Dust Is a Main Factor In Economizing Cost of Producing Pig Iron.

By F. H. WILLCOX.

On January 1, 1921, the rated capacity of the United States was 43,000,000 tons of pig iron per year. The highest ratio of output to rated capacity was reached in September, 1918, when 93.5 per cent of rated capacity was attained. Perhaps it may be assumed that 75 per cent of rated capacity may be realized in an average good year, with a normal stimulus of sales prices commensurate with costs of raw materials, freights, labor, materials and fixed charges. This is 32,000,000 tons of pig iron per year.

Practically 4,250 pounds of ore are now required per ton of pig iron, indicating a yearly requirement of 61,000,000 tons of ore. Of the 4,250 pounds of ore charged per ton of pig iron, less than 4,000 pounds is actually recovered as pig iron. There is an appreciable loss of metallic iron in the slag and a very considerable loss of iron in the flue dust.

Flue dust losses vary. As high as 600 pounds of flue dust per ton of pig iron is on record for a number of blast furnaces over the duration of their blast campaigns. As low as 60 pounds of flue dust has been established at certain operations producing as much tonnage as with the higher dust production rate.

From considerable data it is apparent that the average rate of flue dust production is as follows:

Pounds of flue dust per ton iron at dust catcher	150 pounds
Pounds of flue dust per ton iron at gas cleaning system	95 pounds
Pounds of flue dust per ton iron through gas cleaning system	5 pounds
Total pounds flue dust per ton iron	250 pounds
Equivalent iron ore lost	225 pounds
Iron ore charged	4,250 pounds
Loss	5.5 per cent
Tons flue dust per day—500 tons pig iron	
At dust catcher	33.5 tons
At gas cleaner	20 tons
At stoves and boilers	1.15 tons
Grains dust per cubic feet gas after dust catcher	10.8 grains
Grains dust per cubic foot gas at dust catcher	4.8 grains
Grains dust per cubic foot gas at gas cleaner	4.8 grains
Grains dust per cubic foot gas after gas cleaner	0.2 grains

If dry cleaners are used after the dust catcher practically all the 20 tons per day may be recovered if suitable tight conveying systems are used and the dust mixed with water in a pug mill to about 12 per cent moisture content before discharge into cars. The less effective cleaning usually attained in dry cleaning systems may slightly reduce the amount of dust recovered from 20 to 18.5 tons, and increase the amount going into the stoves and boilers from 1.15 tons to 2.85 tons per day. If wet washers are used about 95 per cent of the equivalent dry 20 tons of dust may be recovered by suitable settling basins, leaving 1.00 ton going to the sewer. These figures correspond to about 210 grains of solids in washer discharge water and 11 grains in settling basin discharge water.

To summarize average practice today, it may, therefore, be said that of a total of 54.65 tons of flue dust produced per 24 hours, 52.5 tons may be recovered, leaving about 2¼ tons going in part to the stoves and boilers, and in part to sewers, the proportion of the dust in either case depending upon the type of gas cleaning plant used.

It is indicated, therefore, that for a pig iron production of 33,000,000 tons per year, something like 3,500,000 tons of flue dust is actually produced, probably equivalent to 3,100,000 tons of ore per year, or 1,635,000 tons of pig iron per year, or the product of nine 500-ton blast furnaces for one year.

Of the above flue dust production it appears from the basis of data from a considerable number of operations applied to the total, that approximately 80 per cent of the total dust catcher dust is re-used, either raw, sintered, nodulized or briquetted. This amounts to less than half of the total, or 1,700,000 tons of dust catcher dust re-used per year; 1,800,000 tons are not accounted for.

This 1,800,000 tons is very largely shot into the air and distributed over the country or city at plants not having gas cleaning plants. Surprisingly little stays in the stoves or boilers out of the tremendous amounts passed through in 90 or 120 days. For this very reason the amounts of flue dust made are not commonly supposed to be as great as mentioned. At furnace plants having gas cleaning plants, wet or dry, by far the greater amounts of dust either carried in washer water or recovered dry are allowed to escape into streams or sent out for fill. Usually over 95 per cent of these dusts will pass through a 100 mesh sieve. It is not commonly realized what really high quantities are allowed to escape. It is the writer's estimate that of the 1,800,000 tons mentioned in this paragraph, quite probably 1,500,000 tons are never recovered.

This 1,500,000 tons yearly loss of flue dust would be equivalent to about 1,350,000 tons of ore, or about 700,000 tons of pig iron, the yearly production of four 500-ton blast furnaces. The loss of labor, coal, boat trips and pig iron production is, in the aggregate, a very considerable item. In fact it is a very considerable item even for a single 500-ton blast furnace, and for the so-called average 500-ton stack it totals up to 11 tons of pig iron lost per day—with whatever that means in cost of equivalent tonnage of ores delivered to the furnace top and lost profits in the pig iron tonnage in question. A fair guess would be:

Cost of 21 tons ore at $6.55	$136.00
Profit on 11 tons pig iron at $3.00	33.00
	$169.00
Loss per ton pig iron	$ 0.34

The question of ores lost as flue dust in consequence of slips is, in the writer's opinion, a minor item. Tight top furnaces and gas cleaning systems recover virtually all such dusts, or at least make possible the recovery. Moreover, the relation of magnetic and non-magnetic proportions of flue dust indicates that by far the greatest proportion of dust arises from the normal movements of the gases and burden, and not from slips.

The reduction of these losses is a practical problem and not one fraught with any particular difficulties. Considering that the ores, or flue dusts, carried out of the dust catcher are fine and as a matter of fact exactly as rich in iron as the burden, that a gas cleaning system aside from its other advantages makes recovery possible, that up on the range millions of dollars are being expended to mine, beneficiate and prepare leaner ores than our flue dusts, it would appear quite practicable to recover and use all of the dusts made, barring possibly 2.5 tons which are inevitably lost in the system.

One logical step is the further development of furnace lines, coking practice, limestone preparation and adjustment of practice to reduce to a minimum the production of flue dust from the ores which must be used. It appears perfectly practicable and to be expected that with time for the changes involved, the average plant can reduce flue dust production to less than 125 pounds per ton of iron. This in fact is being accomplished at three plants at least, and probably more. This corresponds to a total production of about 33 tons of flue dust per day per 500-ton furnace, dust catcher, gas cleaner and unremoved from gas.

The other step is recovery and use of dust made. No mention is necessary of the practicability of recovery and preparation of dust catcher dust as it is an accomplished fact. As for gas cleaner dusts, about 20,000,000 tons furnace capacity is equipped with secondary cleaners, wet or dry type. This is nearly half the total capacity and probably is more than half of the usual capacity that actually operates on more or less full time. It is believed that 1,000,000 tons of flue dust are lost at these plants every year. These dusts can be recovered for a capital expenditure, per 500-ton plant, of certainly less than five cents per ton pig iron for plant, and less than fourteen cents per ton pig iron for plant operation. This would net fifteen cents per ton pig iron, or about $27,500 per year for a 500-ton furnace, over and above extinguishment charges on equipment cost and labor and material in operation of recovery and preparation plant.

Although a minor point, it may be pointed out that complete recovery of flue dust is worked out to afford a practically dustless plant. This would perhaps have been beside the point not so long ago, but at least three plants today have taken steps—all with a different plan—to obtain positive relief from the nuisance of clouds of flue dust.

In view of the increasing expenditures resorted to for securing ores, and the evident necessity of economies in pig iron production, however obtained, both the reduction in amount of flue dust produced and the recovery and use of all dust unutilized is bound to be of increasing importance.

NEW METHOD OF MANUFACTURING CAST IRON AND STEEL IN FRANCE.

It is reported that the Basset Steel Works (Aciéries Basset) have recently discovered a new method of manufacturing cast iron and steel. Mr. Lucien Basset states that, after having obtained satisfactory results in a furnace of 25 tons capacity, he has this month made conclusive experiments in a 100-ton furnace resulting in the manufacture of steel at a cost of 110 francs a ton. This is less than the averafie pre-war cost. Mr. Basset has also stated that his company will begin in the course of a few weeks the construction of 12 furnaces having a total daliy capacity of 3,000 tons of steel. He estimates the total cost at 30,000,000 francs.

According to this method the coal which is consumed in the furnace enters into the manufacture of metallurgical products simply as an element producing heat and not as an element which throws out gases acting on the raw material. It appears that the application of these principles results not only in an important economy of fuel, but also eliminates the necessary of utilizing coke. Consequently the discovery of this process is of considerable importance to France.

PLAN TO BUILD MILL.

Proposed construction of a factory and rolling mill at an estimated cost of $600,000, at Louisville, Ky., by the Collapsible Rim Manufacturing Company, Ashville, N. C., is reported. According to the report the Collapsible Rim Manufacturing Company has purchased the conveyor machinery plant of the Buzz Engineering Co., which will be utilized for some time, but which will be supplanted by new structures later.

Discussion on Open Hearth Practice

Some Facts To Be Considered In Relation to Open Hearth Furnace Temperature to Furnace Output.

By HENRY WILLIAM SELDON, B.S., Met.Eng.,
See-Seldon & Associates.

OBSERVATION and experience with open hearth furnaces using producer gas in the past has shown the furnace output per hour to follow a general curve such as shown in Fig. 1.

Practice has shown that the life of a furnace is dependent upon many factors, namely, construction, drying out, heating up, regulation, operation and attention.

This is the second installment of a series of articles to be written by Mr. Seldon on Practical Open Hearth Furnace Practice. Mr. Seldon, before joining Theodore S. See in forming the See-Seldon and Associates Engineering firm, spent ten years in open hearth work with the Cambria Steel Company and the Jones and Laughlin Steel Company. The many experiments made during his operating career make him particularly suited to write on this interesting subject.

If we assume a new furnace as constructed to a proven design, built to exact dimensions at all points and the workmanship first class, we will have provided only the rough tools and the resulting life of the furnace, total tonnage and tons hour output will still be unknown factors.

There has been considerable discussion as to the length of time which should be spent upon the operations of drying out and heating up, but to our mind it is much better practice to err upon the side of taking plenty of time for these operations.

It should be remembered that not only must the body of the furnace be considered but likewise the downtakes, slag pockets, checkers, flues and stack must also be dried out and heated up gradually.

Moisture is present not only on the exposed surfaces of the bricks, but likewise completely through the exposed brick as well as the bonding material and brick making up the unexposed parts of the furnace. Many of these walls are 18 inches and more in thickness.

After the moisture has been removed from the furnace the heating up process is gradually increased. This should be increased very slowly at first in order to allow the center of the exposed brick to become heated and prevent not only spalling off on the surface, but also to prevent hidden cracks forming by too rapid expansion. Until the exposed brick have assumed a red heat all flame should be prevented from touching the brickwork.

The practice of making bottom on a new furnace before charging is a very good one and the additional seasoning of the roof and the heating up of the downtakes, checkers, etc., is very beneficial and very often prevents the gas from traveling to the roof after the furnace has been charged.

It is a well-known claim among furnace men that the better seasoned a furnace is the faster it will make steel later on without damage to the brickwork. The continual heating of the roof brick has the effect of rendering it better able to withstand high temperatures without burning.

To our mind the reason for the roof brick being better able to withstand high temperatures after, say 50 heats have been taken out, is due to the physical condition of the roof at that time. During the early life of a furnace the roof is more or less irregular and the bricks are porous. Later on the roof is worn smooth and the bricks become glazed, and if the furnace is working and handled properly the roof becomes a smooth arch reflector against which the heat rays have less penetrating effect and we get the equivalent of a roof with a higher fusing point. This becomes so pronounced in an occasional furnace that you hear the first helper say you can't burn the roof. Such a statement as this is of course not meant literally, but only in a comparative sense.

This condition of roof should be the aim to procure on every furnace, but it is only obtained after careful and painstaking work on the part of all concerned.

When we have a furnace in this stage we are in a position to expect and obtain an increase in the tons per hour output without damage other than the unavoidable wear and deterioration which always goes on.

A furnace working properly heats up the charge and not the roof and side walls. An exception to this is true for all furnaces while charging and while the scrap is high on the ends on account of the gas being deflected. This condition very often necessitates either quicker reversing or a slacking up of the gas until the danger is eliminated, otherwise the gas will strike the brickwork and cause untold damage in a very short interval.

It is the quantity of heat or temperature developed by the flame over the bath and the extent to which this flame, visible or invisible, covers the bath that determines the tons per hour output of the furnace.

The higher the temperature developed the more rapidly will the scrap melt and the faster will the charge approach the temperature of the flame.

As the heat progresses and the lime begins to come up conditions change and we have stages during which the bath instead of absorbing the heat reflects it and it becomes imperative to slow up the gas to prevent burning the furnace.

What is required is an adjustable flame and means to increase the intensity and quantity at such times as the bath will absorb the heat. To be able to increase the intensity of the flame without damage to the walls and roof of the furnace is what is required.

Furnace temperature is not always an indication of a rapidly working furnace, in fact the converse is often true. Usually in the best working furnace the brickwork is comparatively cool, while in an old furnace which is not working the bricks are white hot continually. The heat must be supplied to the bath and not the walls and roof, this means the flame must keep to the bath.

In the majority of furnaces there is a cycle of conditions or speed of working. During the first stage of the run it has often been impossible to get the furnace to work sharply in spite of all attempts at regulation. Later for no apparent reason the furnace starts working sharply and continues to work with this quality for several weeks. In time the furnace begins to slow up and in spite of all attempts at regulation or forcing of the furnace the time of heats continues to increase. This condition gradually gets worse and usually because of continued forcing the roof and walls are burned away and the furnace is taken off.

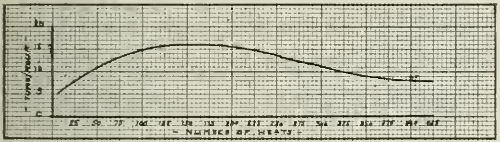

Fig. 1.

The point aime dat in the preceding paragraph is to try to show that there is "a something" about the operation or construction of an open hearth furnace which has not been fully understood. Some furnaces go through an entire run without ever attaining this desired condition.

By a furnace working sharply is usually meant one which cuts down the scrap quickly, can produce results with less gas, flame lays down over the bath, roof and walls cooler than flame, lime comes up quickly and at all points, good reactions from additions of hot metal, carbon burns out of bath quickly and bath heats up to tapping temperature quickly.

It has been suggested that "this something" which makes an open hearth furnace work sharply is "blow pipe action" and it sounds logical.

Blow pipe action is influenced by the individual pressures, velocities, proportions and relative directions of the incoming gas and air, and the temperature developed is influenced by the degree of preheating and the type of fuel.

An open hearth heat may be divided into four general stages as follows:

1. Time of charging
2. Time melting down
3. Time of reaction
    a. De-phosphorizing
    b. Refining.
4. Time bringing heat up to casting temperature.

It would appear the benefit derived from an increased flame temperature would be noticeable during stages 1, 2 and 4.

Stage 3 appears doubtful on account of the process of de-phosphorization taking place at a lower temperature and being incomplete when the bath is excessively hot, as results with duplex have shown.

The process of refining among other reactions consists of removing iron oxide (Fe_3O_4) from the bath by carbon (Fe_3O_4 plus 4C equals 4 CO plus FE_3).

During the periods which this gas is being given off by the bath the incoming fuel gas is deflected to the roof and must be slacked down.

In stage No. 1 the limiting factors are the deflecting of the incoming flame by the scrap in such a manner as to injure the brickwork. Likewise the presence of flame in the furnace being a hindrance to the charging machine operator by increasing his chances for damaging the furnace roof by pushing a hole in it with scrap, also in his efficiently charging the furnace.

In stage No. 2 we see only beneficial results from higher flame temperature.

In stage No. 4 it should be possible with a flame temperature equal to that of natural gas to reduce the time at least one hour and in most cases eliminate it entirely so that by the time the bath is refined the heat will be hot enough to pour.

There is a temperature limit for the bath of an open hearth furnace above which it would not be advisable to go, namely, the fusing point of the banks. The danger line appears to be but a few degrees above the present casting temperature especially when a heat is held in the furnace for a short time after it is ready.

Other features to be considered before increasing the bath temperature are the pollution of the bath with iron oxide and the formation of a thin slag. These are important from the standpoint of quality of the steel and also the chemical action of a thin slag upon the open hearth banks.

FOUNDRY EXHIBITION IN 1922.

The uncertainties which for some time have surrounded the 1921 exhibition of the American Foundrymen's Association have been cleared up in a statement just issued by C. E. Hoyt, secretary of the association, from its offices at 140 South Dearborn Street, Chicago. Both the time and place of the exhibition of this year have been under consideration and there has also been discussed the question of postponement. At a meeting of the executive committee of the association held in New York, May 28, it was decided to hold the next convention and exhibit in April or May at a place to be selected by the Committee on Convention and Exhibits. Part of the statement of Secretary Hoyt is as follows:

"From the date of organization to 1911 the conventions of the American Foundrymen's Association were held in May or June of each year. In 1912 it was found necessary to postpone the convention scheduled for June at Buffalo until late in September, due to delay in completing the building in which the exhibits were to be placed, and since that time the annual meetings have been held in the fall.

"At the annual meeting of the board of directors of the association, in Rochester, N. Y., December 7, 1920, invitations for the next convention were referred to the committee on convention and exhibits. When this committee met in Cleveland on March 30 to consider the place of the next meeting it was found that in none of the eight cities considered was it possible to find, during September or October, adequate hotel accommodations and exhibition facilities to properly care for such meetings as were held in 1919 and 1920.

Electric Furnaces for Making Steel

General Features and Advantages of the Keller Furnace and of the Stobie Furnace — Classification of Electric Steel-Making Furnaces.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART V.

CHARLES ALBERT KELLER, Managing Director of the "Société des Etablissements Keller Leleux," Livet Works, Isère, France, developed a furnace* of the series-arc type that resembles the Heroult furnace except in regard to the method of supporting the electrodes. The main peculiarity of his furnace consists in the fact that the electrode supports are not attached to the furnace. and that in consequence the electrodes must be lifted out of the furnace before the latter can be tilted to pour the charge. The independent support of the electrodes offers certain advantages, but interferes seriously with the easy tilting of the furnace and also means that the electrodes will be exposed to the air, while red hot, and that the holes in the roof through which the electrodes enter will be open while pouring the charge, and will allow the entrance of air and the exit of heat and gases from the furnace. In the early days of electric furnaces, when electrodes had to be changed as soon as they became too short for use, this method had some advantages; but the use, as at present, of threaded electrodes that can be lengthened so as to avoid the waste of stub-ends, seems to leave less advantage for this special form of construction. It may be added that the same method of electrode support was adopted by Nathusius in his first furnace which was employed in Friedenshutte. Germany, about the year 1912.

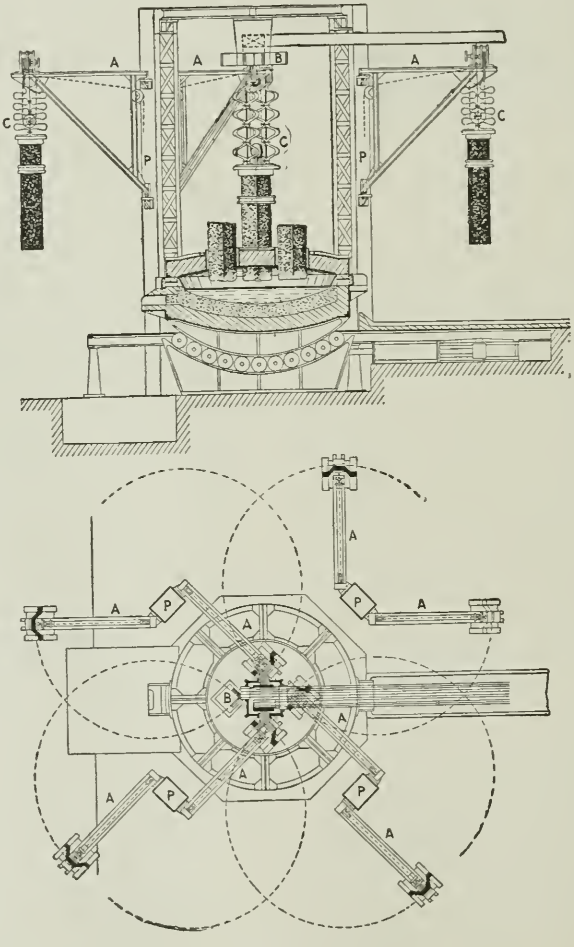

Fig. 24—Keller Steel Furnace.

The Keller furnace shown in Fig. 24, was circular in plan and had four electrodes which were supplied with single-phase current. In a modern installation it is probable that two-phase current would be used with four electrodes, or three-phase current with three or six electrodes. The furnace is supported on a train of rollers and can be tilted, like the Campbell open-hearth furnace, by means of a hydraulic ram. The electrode holders are not attached to the furnace, but are suspended from independent supports, and the furnace cannot be tilted until the electrodes have been withdrawn. The system for supporting the electrodes is shown in the figure.

Each electrode hangs from the end of a hinged arm. A, and two of these arms are supported on each of the four pillars, PP. There are thus eight electrodes, of which four are in use at once and the other four are ready to replace these when they become too short for further use. To replace an electrode it is lifted up to clear the furnace, swung out of the way and a fresh electrode swung over the furnace and lowered into position. Electrical connection with the electrode holder is made by the flexible metallic conductors, CC, which fold up when the electrode is raised; a vertical rod, serving to keep them in place. Electrical connection to these conductors is made by a fixed system of bus-bars. B. with which each electrode arm engages when it is swung into position. The electrodes are. therefore, automatically disconnected from the electrical supply when removed from the furnace for changing. The four-electrode furnace shown. having two pairs of series-arcs, has nearly perfect symmetry of heating. It has also the advantage that the electrical supply bus-bars, being all brought to the same point, can be thoroughly interlaced and thus the inductance of the system can be kept low and the power-factor can be as high as 0.97 with 12,000 amperes.

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* C. A. Keller, "A Contribution to the Study of Electric Furnaces as applied to the Manufacture of Iron and Steel," Trans. Am. Electrochem. Soc., XV, 1909, page 110.

The furnace was used to finish steel that had been made in the open-hearth furnace. A charge of 7.5 tons of steel containing 0.15 per cent carbon, 0.06 per cent sulphur, and 0.007 per cent phosphorus, required two hours and 45 minutes in the furnace with an average power of 750 kw; yielding a steel having 0.443 per cent carbon, 0.009 per cent sulphur, and 0.008 per cent phosphorus. The energy consumed per ton was 275 kwh. The electrode loss was about 26 pounds, costing 80 cents per ton of steel. This figure apparently does not include the cost of the waste ends and should probably be somewhat higher.

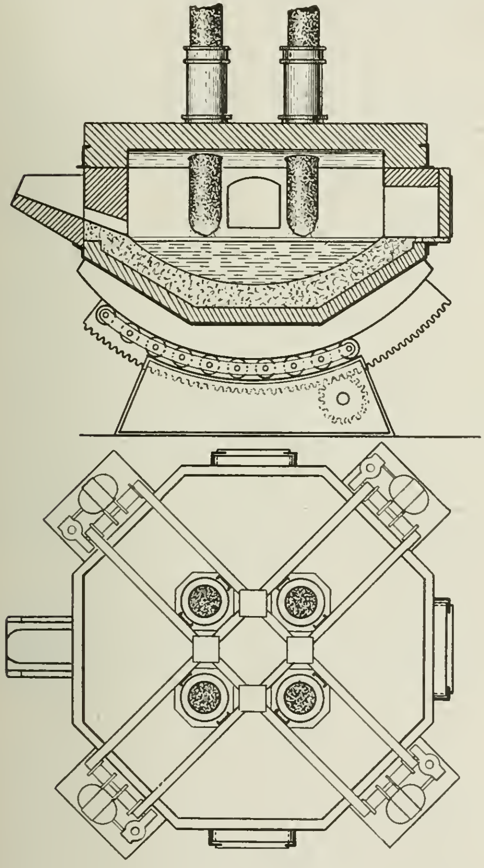

Fig. 25—15-ton Stobie furnace.

Stobie Furnace.*

This is a recent form of series-arc furnace which was employed in the North of England during the war. It has been made in sizes up to fifteen tons and the electrical design has varied considerably in the earlier types. The newer furnaces, which have four electrodes and use two-phase current, will be described here.

The 15-ton furnace shown diagramatically in Fig. 25, is octagonal in plan and has four electrodes arranged in a square. It rests on a train of rollers and is tilted by a 15 hp motor. The furnace can be tilted towards the working platform for pouring off the slag, and away from it for pouring the steel. The electrodes are supported and guided by means of a braced steel cross, which is shown in the plant but not in the elevation, and are lifted and lowered by motors which rest on the four corners of the furnace shell. The roof is arched in one direction only. The electrodes are supplied with two-phase current; though in an earlier form, star-connected three-phase current was used, and the fourth electrode was connected to the neutral point, thus carrying any unbalanced current. "Electrode Economizers" are used, which consist of light sheet-steel cylinders somewhat larger than the electrodes, which they enclose, and about two feet long. The lower end of each is sealed to the arch with fire-clay and its upper end is covered with a plate which fits the electrodes. This arrangement prevents the wasting away of the red-hot electrodes by oxidization in the air.

A 15-ton furnace at the works of the Stobie Steel Company at Dunstan-on-Tyne was making nichrome-steel heats in six hours from tap to tap, making twenty-four heats each week. The power consumption was 600 to 625 kw hours per ton of saleable ingots, with a melting loss of 2½ per cent of the charged metal. The output of the furnace was 1,000 tons per month. The roof was replaced every third week, but was not worn out in that time. The power supply is not stated, but from the above data it would appear to be about 1,500 kw, which is rather small for that size of furnace.

The furnace at Dunstan-on-Tyne used the star-connected three-phase system of electrical supply with a connection from the neutral to the fourth electrode. This system appears to be satisfactory except that the fourth electrode will receive a variable amount of power which will in general be less than that supplied to the other electrodes. In the newer, two-phase system, each pair of diagonally opposite electrodes is connected in one of the electric circuits of the two-phase supply. This arrangement is more symmetrical than the other, but it has this drawback, in common with a single-phase furnace, that if one arc breaks, the arc in series with it will also break and both electrodes must be lowered before either arc can be restarted. The regulation of the electrodes, also, cannot be controlled by the current flowing to each electrode, as in a three-phase system, but will have to be operated by the voltage between each electrode and the body of the furnace.

THE ELECTRIC BLAST FURNACE.

In "La Technique Moderne" an article recently appeared reviewing the introduction, actual state of development, and the future of electric blast furnaces. The process of the reduction of iron ores is treated analytically, calculations for determining the quantity of carbon necessary for the reduction of impurities being included. A heat balance-sheet is also given.

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*"Stobie 15-ton Electric Furnace," Iron & Coal Trades Review, April, 1918, p. 402.

Molybdenum and Molybdenum Steel

Occurrences of Molybdenum — Manufacture — Properties and Uses — Molybdenum In Steel, Over One Per Cent, Less Than One Per cent — The Manufacture of the Steel Itself.

By ARTHUR H. HUNTER,[*]
President, Atlas Crucible Steel Company, Dunkirk, N. Y.

PART II.

The Manufacture of the Steel Itself.

THE production of some 50,000 tons of molybdenum steel has served to place melting practice on a firm basis. Molybdenum may be added to the electric or open-hearth bath either in the form of calcium molybdate or ferro-molybdenum. Greater precautions are necessary in the open-hearth with the former than with the latter. In this type of furnace the method which has been found most advantageous is to make the addition as the charge is melting down and before the slag has formed. This practice insures a complete and uniform diffusion of the molybdenum through the steel. In this process nearly all of the molybdenum remains in the steel and losses, whether mechanical or due to volatilization and oxidation, are extremely small. The molybdenum in scrap can be recovered when remelted in like proportion to the original addition. The total alloy efficiency in average practice is well over 90 per cent. In the electric furnace the positive control of slagging and atmospheric conditions renders an even higher recovery possible.

The statement appears in a recent paper by Charles McKnight, Jr.[‡]

> "There are no especial precautions that should be taken in either pouring or rolling, except those which would be taken with any alloy steel, and it will usually be found that the percentage of product will be greater and the rejections for seams, segregations or piping less with molybdenum steel than with corresponding grades of alloy steels. This is particularly noticeable when a chrome-molybdenum steel is compared with a nickel-chrome."

Observations of a like nature are made by Martin H. Schmid[°]

> "The blooming and finish rolling operations on molybdenum steel requires no special precautions other than those necessary on corresponding types of other alloy steels, and the practice, measured in per cent. of available finished product, is higher than in most types of similar properties. The tendency toward a minimum amount of inherent defects, both surface and sub-surface, is very pronounced, especially as compared with nickel and chrome-nickel steels.
>
> "Wide temperature ranges are available for rolling and forging, and, while there is no appreciable difference in the amount of scalage, there is a marked advantage in the texture of the scale over that on nickel steels. The scale is a loose, non-tenacious one, freely flaking from the steel, showing no tendency to roll into surface and result in pitting."

Our own experience confirms the actual performance of molybdenum steel in mill operations and the manifest ability of molybdenum steel to process with pronounced ease and satisfaction.

The Physical Properties of the Finished Steel.

Molybdenum steels, as a class, when compared with other alloy steels which are in the same category from a commercial standpoint, treated to the same tensile strength, show:

1. A slightly higher elastic limit, hence a somewhat higher elastic ratio.
2. A higher elongation, hence greater ductility.
3. A much higher reduction of area, hence appreciably greater toughness.

This latter property is probably the most pronounced individual physical result of the addition of molybdenum to steel. From a great deal of data covering these three points, the writer has chosen the following tests, made under the supervision of Dr. J. S. Unger of the Carnegie Steel Company, as exemplifying them in the simplest manner.

Five steels, embracing only the accepted commercial tonnage types, analyzing as shown in Table A, were all heat treated to give the same tensile strength, i. e., approximately 125,000 pounds per square inch. The results were as shown in Table B.

Table A—Analyses.

Type of Steel	C	Mn	Ni	Cr	Mo
1. Carbon	.62	.45	...	...	...
2. Chrome	.49	.53	...	.60	...
3. Nickel	.40	.65	3.61	...	...
4. Chrome-nickel	.43	.57	1.60	.46	...
5. Chrome-molybdenum	.32	.72	...	.80	.27

Compared with the carbon steel, the chrome-molybdenum showed 33 per cent increase in elastic ratio, 16 2/3 per cent increase in elongation and 56 per cent increase in reduction of area. Compared with the nearest alloy steel, the chrome-molybdenum showed 1.7 per cent increase in elastic ratio, a little over 6 per cent increase in elongation and 12.8 per cent increase in reduction of area. The tensile strength of

Table B—Physical Properties.

Type	Tensile Strength Pounds Per Square Inch	Elastic Limit, Pounds Per Square Inch	Elastic Ratio	Per Cent Elongation in 2 Inches	Reduction of Area, Per Cent.	Izod Foot Pounds
1. Carbon	126,175	84,380	66.9	18.0	43.6	5.0
2. Chrome	125,300	107,225	85.6	18.0	56.5	66.5
3. Nickel	127,975	112,525	87.9	18.8	51.4	54.5
4. Chrome-nickel	127,975	111,025	86.8	19.8	60.3	54.0
5. Chrome-molybdenum	125,650	112,250	89.3	21.0	68.0	90.0

[‡] "Molybdenum Steels." Trans. Amer. Soc. Steel Treaters. March, 1921).

[°] "Molybdenum Steel and Its Application." Amer. Soc. Steel Treaters (presented April, 1921).

[*] Paper presented at the American Iron and Steel Institute, May 27, 1921.

all these steels having purposely been made the same, the only possible variables were these three.

The physical merit of a steel depending upon the relation of all its properties, it is the cumulative effect the increase of each that gives to the molybdenum steels their superior merit. In this connection reference is made to the paper by J. D. Cutter* proposing the use of a merit index, developed by H. T. Chandler, for the comparison of different steels by employing a formula embracing the four static properties and indicating roughly the work done in breaking a test piece.

In direct relation to the foregoing, it should be noted that tests by the Izod machine on these steels showed chrome-molybdenum to possess a resistance to impact of 18 times that of the carbon steel and 34 per cent greater than the nearest alloy steel. As the impact test merely measures the work of rupture under a suddenly applied load, these results, which have been amply corroborated, clearly show the cumulative effect of the higher elastic ratio, elongation and reduction of area for a given tensile strength possessed by the molybdenum steels. Bending tests further bear this out.

In order to give an idea of how the chrome-molybdenum series of alloy steels compares with chrome-vanadium steels, a comparison of two types of each follows. The data on both of the chrome-vanadium steels is taken from a recent booklet published by the Vanadium Corporation of America presenting charts plotted by the Metallurgical Department of the United Alloy Steel Corporation. The data on both of the chrome-molybdenum steels was furnished the writer by the Metallurgical Department of the same company. Both series of tests were made on open-hearth steels.

Type 1—.40 to .50 Carbon.

Type	C	Mn	Cr	V	Mo
Chrome-vanadium	.47	.85	1.19	.15	...
Chrome-molybdenum	.41	.68	.95	...	.24

Sections, ⅞ inch round, quenched in oil from 1560 degrees F. (V.) and 1500 degrees F. (Mo.). Drawn to show tensile strengths indicated.

	——250,000 lbs. T. S.——		
	E. L.	El. %	R/A.
Cr-V.	215,400	11.0	38.5
Cr-Mo.	222,000	9.0	43.5

	——225,000 lbs. T. S.——		
	E. L.	El. %	R/A.
Cr-V.	201,000	12.3	42.3
Cr-Mo.	201,000	10.3	47.9

	——200,000 lbs. T. S.——		
	E. L.	El. %	R/A.
Cr-V.	184,000	14.0	47.0
Cr-Mo.	179,000	13.3	52.2

Type 2—.23 to .30 Carbon.

Type	C	Mn	Cr	V	Mo
Chrome-vanadium	.27	.71	.98	.15	...
Chrome-molybdenum	.28	.64	.70	...	.20

Sections, ⅞ inch round, quenched in water from 1625 degrees F. (V.) and 1525 degrees F. (Mo.). Drawn to show tensile strengths indicated.

	——175,000 lbs. T. S.——		
	E. L.	El. %	R/A.
Cr-V.	157,300	15.0	60.5
Cr-Mo.	163,400	15.5	59.3

	——150,000 lbs. T. S.——		
	E. L.	El. %	R/A.
Cr-V.	137,500	17.7	62.8
Cr-Mo.	141,200	18.7	63.4

	——125,000 lbs. T. S.——		
	E. L.	El. %	R/A.
Cr-V.	112,400	21.2	66.9
Cr-Mo.	117,800	22.8	69.0

It should be noted that the molybdenum content of both of these types of the chrome-molybdenum steel is extremely low. For a comparison on a purely commercial basis, steels containing double the above content of molybdenum and showing higher physical properties might well have been used. Considering the lower manganese, chromium and molybdenum contents of the last mentioned molybdenum steel, a comparison between its properties and those given in the table of Dr. Unger is interesting.

It has been stated above that the physical properties of molybdenum steel were progressively better as the molybdenum content is increased up to 1 per cent, and the table of properties below is presented to illustrate this point:

Sections, 1¼ inch round and 1¼ inch square, quenched in water from 1550 degrees F. to 1600 degrees F. Drawn to show a tensile strength of 175,000 lbs. per square inch.

Analysis Range.

C	Mn	Cr
.28 to .36	.44 to .64	.70 to 1.04

Progressive Effect

	Mo .20	Mo .40	Mo .76
Elastic limit	167,000	164,000	162,000
Elongation per cent in 2 in.	13.5	16.6	19.5
Reduction of area, per cent	52.0	58.4	61.0

For a constant tensile strength and very nearly constant elastic limit, the ductility of the steel is greatly increased by the addition of molybdenum from .20 up to .76. Conversely, of course, by employing suitable drawback temperatures, for a given ductility the elastic limit and tensile strength will show an increase in like manner.

The comparative effect of increased section on chrome-molybdenum and chrome-vanadium steels is shown by the following average results on different sizes of both, taken from tests on commercial stock.

Analysis Range

	C	Mn	Cr	V	Mo
Cr-V. ...	.23 to .30	.60 to .80	.70 to 1.00	.15 to .20	....
Cr-M. ..	.23 to .30	.60 to .80	.70 to 1.00	....	.25 to .35

The more complex quarternary alloy steels containing molybdenum show extremely high characteristics, as will be seen by reference to the following tables. Both of these steels can be drawn back to better than 1,000 degrees F. before the tensile strength falls below 200,000, and to 900 degrees F. before the elastic limit falls below this figure. The steel containing nickel exhibits remarkable physical properties at low drawing temperatures such as are employed in the production of oil hardened gears, whereas the steel containing vanadium possesses greater possibilities at the higher drawing temperatures.

	C	Mn	Cr	Ni	V	Mo
Chrome-nickel-molybdenum (1)	.44	.42	.99	2.04	...	.36
Chrome-vanadium-molybdenum (2)	.38	.60	1.00	...	.18	.80

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*Suggested Method for Determining Comparative Efficiency of Certain Combinations of Alloys in Steel. Trans. Amer. Soc. Steel Treaters (1920), 1,188.

Effect of Section

Size	Elastic Limit Ca-V	Elastic Limit Cr-Mo	Tensile Strength Cr-V	Tensile Strength Cr-Mo	Elastic Ratio Cr-V	Elastic Ratio Cr-Mo	Elongation Per Cent Cr-V	Elongation Per Cent Cr-Mo	Reduction of Area Cr-V	Reduction of Area Cr-Mo
1 3/32 inch ...	134,200	134,800	153,200	156,200	87.6	86.2	16.8	16.8	57.1	59.0
1 1/8 inch	123,100	132,300	145,500	153,700	84.7	86.3	15.8	16.3	55.8	56.8
1 5/16 inch ...	116,900	133,500	150,300	153,200	77.7	87.1	15.1	16.8	53.2	56.5
1 11/16 inch ..	103,200	124,600	137,500	152,200	75.3	81.9	14.0	16.3	46.3	55.4

Sections, ⅞ inch round (1), quenched in oil from 1,450 degrees F., and 1⅛ inch round (2), quenched in oil from 1600 degrees F., both drawn as indicated.

Results of Tests on (1)
Chrome-Nickel-Molybdenum Steel

Drawing Temp. F.°	Tensile Strength	Elastic Limit	Elongation Per Cent in 2 Inches	Reduction of Area Per Cent
400	336,600*	302,000*	10.0*	22.4*
600	275,000	241,000	11.3	43.0
800	240,000	220,000	12.0	46.0
1,000	204,000	185,000	15.0	51.0
1,200	152,000	134,000	20.5	61.0

*Section treated .505 inch round.

Results of Tests on (2)
Chrome-Vanadium-Molybdenum Steel

Drawing Temp. F.°	Tensile Strength	Elastic Limit	Elongation Per Cent in 2 Inches	Reduction of Area Per Cent
600	243,000	217,000	9.0	38.2
800	225,000	207,000	10.8	45.4
1,000	210,000	197,000	14.0	52.5
1,200	186,000	174,000	18.2	59.7

A low carbon steel to which about ¼ per cent. molybdenum is added possesses extreme ductility which makes it particularly adapted in sheet form to the manufacture of pressed steel parts and at the same time when heat treated is capable of showing fairly high physical properties. Tests made on such a sheet steel, test piece—1½ inch wide by 9 inches long, follow:

Thickness of Sheet	Condition	Elastic Limit, Pounds per Square Inch	Per Cent Elongation in 2 Inches
5/32 inch	As rolled	45,640	44.5
5/32 inch	Quenched*	120,470	7.5

*Quenched in water from 1,600 degrees F. and drawn to 900 degrees F.

Analysis = C .164 Mn .45 Mo .226

Molybdenum steels also have the property of deep hardening, especially noticeable in the chrome-molybdenum series. Their properties are developed at higher drawing temperatures than employed with other steels, a fact directly related to their greater toughness and resistance to fatigue.

III. The Adaptability of the Steel to Fabrication.

It is in connection with this, the most important of all practical considerations, that the real commercial value of molybdenum is most evident. In the fabrication of an article from steel there are three fundamental operations:

1. Forging or cold pressing
2. Heat treating
3. Machining

Forging.

Good "forgeability" is determined by three prime factors: a. The manner in which the steel flows; b. permissible range in forging temperatures; c. the extent to which the scale adheres to the steel.

The molybdenum steels flow readily under the dies and possess a wider safe forging range. It is in the ability to "throw the scale," however, that their chief advantage in forging lies. The scale on nickel and chrome-nickel steels adheres strongly to the bar, while that on the chrome-molybdenum comes off readily. Adhesion of scale during working naturally increases the prevalence of pits and other surface defects, hence aside from minimizing actual forging rejections the molybdenum steels show a smoother surface after hot working.

A loose scale such as that particularly characteristic of these steels is largely removed by the quenching operation during heat treatment, thereby eliminating pickling and hand cleaning of forgings before machining. Thus the general manufacturing difficulties due to scale are minimized.

Cold Pressing.

In sheet form, straight carbon molybdenum steel has proved to be, because of its great ductility, especially adaptable to parts which require extremely difficult forming operations. Also this steel can be treated to exhibit high strength and these qualities have made possible a much wider application of heat treatment to sheet metal parts than has heretofore been possible, as is indicated by the recent adoption of molybdenum steels by manufacturers of such commodities as automobile frames and implements such as shovels.

Heat Treating.

A wide, safe heat treatment range is another characteristic of these steels. In hardening, a temperature variation of 200 degrees F. is permissible, while in drawing, the properties fall off less rapidly and higher temperatures are used than with any other alloy steels.

A great deal of data has been published to show that the static physical properties of molybdenum steel are practically constant over a wide range of temperature for quenching. The following tests made under the supervision of Martin H. Schmid,* of the United Alloy Steel Corporation, show that dynamic properties as represented by the Izod impact test, are practically constant over a range of quenching temperatures of 500 degrees F.:

Analysis = C .27 Mn .66 Cr .83 Mo .42

Sections treated ⅞ inch round. All drawn at 1,050 degrees F.

Quenching Temperature	Elastic Limit	Tensile Strength	Elongation Per Cent	Reduction of Area Per Cent	Brinell Hardness	Izod
1,500	140,000	163,500	18.5	62.7	319	58
1,600	139,500	161,700	17.0	63.1	321	62
1,700	138,400	160,400	17.5	61.7	321	60
1,800	138,300	158,500	18.0	61.5	319	61
1,900	139,600	159,600	16.8	57.9	317	56
2,000	140,000	157,000	17.0	59.0	317	55

While carelessness in heat treatment might result from an undue stressing of this point, the fact that the steels do possess this property is of material importance from the standpoint of the quantity producer. The high drawing temperatures mean greater ease in furnace regulation and the adaptability of the steel to heat treatment results in greater uniformity and fewer rejections.

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*Amer. Soc. for Steel Treaters (presented April, 1921).

For case hardened parts, molybdenum has the effect of greatly toughening the core and of adding hardness and wearing qualities to the case. It also has a very favorable effect as compared with nickel on the penetration of carbon in the carburizing process as is evidenced by the following table vouched for by Dr. Federico Giolitti:

	Proportion of Foreign Material	Velocity of Penetration in Tenths of a Millimeter
Nickel	2.0 per cent	7
Nickel	5.0 per cent	5
Molybdenum	1.0 per cent	9
Molybdenum	2.0 per cent	11

Machining.

Corroborative evidence from a large number of plants including several careful time study checks shows that for a specified elastic limit or Brinell hardness these steels machine much more easily than other alloys. As typical of this experience, the metallurgist of one of the foremost automobile companies in a recent report says:

> "We have demonstrated that for a corresponding elastic limit or Brinell hardness, chrome-molybdenum steel machines much more easily than chrome-nickel and the nickel steels; * * * This quality can be made use of in one of two ways: either by producing parts of much greater strength and possessing a higher factor of safety, or by leaving the physical properties approximately the same as with other steels and effecting a great saving in machining cost and increasing largely the production in the machining departments."

IV. The Total Cost of the Fabricated Article.

These steels being commercially priced, the manufacturing advantages enumerated above make possible both increased production and decreased cost of the finished article.

Bearing on the purely commercial factors brought out in this paper, the following extract from a very exhaustive report by a well-known automobile production metallurgist is of interest:

> "From a very careful consideration of the various alloys on the market, * * * we have come to the conclusion that at the present time the nearest approach to our ideal quantity production steel is one in which the alloying elements are chromium and molybdenum."

The automobile, for example, requires for its construction, steels of probably as wide a range of physical properties as any other familiar manufactured unit. The fewer kinds of steel necessary to meet its varied requirements, the obviously greater the efficiency in production, purchasing, inspection, etc.

Chrome-molybdenum steel of a single type in two or three carbon grades develops under suitable heat treatment a sufficient variation in physical properties to meet all of the demands of motor car construction. This fact has resulted in the adoption of molybdenum steel for the manufacture of all vital parts by some of the leaders in the automotive industry.

This standardization on molybdenum steels has effected the two-fold benefit of simplifying purchasing and inspection and of increasing manufacturing economy.

In order to give this subject the breadth that it deserves, the author has quoted results from various steel mills, but would like to mention here that his own experience in the production of molybdenum steels has confirmed a majority of the data presented.

Conclusion.

In 1905, this country produced a little over 20,000,000 tons of steel and less than 100,000 tons of alloy steel, a ratio in excess of 200 to 1. In 1910, this ratio was reduced to less than 50 to 1, and in 1919 to less than 25 to 1. Thus the production of alloy steel during this period has grown about eight times as fast as that of carbon steel.

For these reasons, the question of suitable alloys and particularly their availability for tonnage production, becomes of greater importance to the American steel manufacturer than ever before.

Besides carbon, silicon and manganese which may be termed fundamental steel alloys, not more than ten of all the known chemical elements have proven of value in steel making. From purely tonnage considerations, the commercial structural steels for moving and stationary parts, subjected to constant or suddenly applied loads, constitute the most important class of alloy steels. Only four of these ten alloying elements have been found to impart to steels of this class sufficient commercially advantageous properties to warrant their adoption. These elements are nickel, chromium, vanadium and molybdenum employed in various combinations.

Of all the alloying elements, molybdenum alone is found in sufficient quantities within our borders to take care of the requirements of the American steel industry. The war showed us this dependence upon foreign supply and the writer believes that, entirely aside from technical considerations, this fact alone is of sufficient importance to warrant the domestic industry in lending its support and coöperation to the development of this unique natural resource.

WHEELS FOR MOTOR TRUCKS.

The Bethlehem Steel Company, subsidiary of the Bethlehem Steel Corporation, has gone into the business of making steel wheels for motor trucks. The first unit of the plant to be used for this purpose is already in operation at Bethlehem, Pa. Sample wheels have already been produced and shown to truck manufacturers, who have shown much interest in the steel company's venture.

The company's new product is described as a structural steel wheel fabricated from specially rolled stock, which is punched, formed and bent in such a way that the flange of the channel becomes the rim of the wheel, while the spokes, shaped from the web, from an interlocking "keystone" hub construction.

"In other words," explains Automobile Topics commenting on the new wheel, "each length of channel stock is blanked out and formed into two pieces, from each of which the spokes project at right angles to the flanges. The spokes are then staggered, and finally the flanges are bent around into a circle, bringing the spokes into their final and proper relation. The ends of the rim are then welded. Two wheels are thus produced from each section of material."

New 18-Inch Continuous Mill

Mill Recently Completed by Whitaker-Glessner Company at Portsmouth, Ohio, Modern In Every Respect.

ONE of the most modern continuous mills in the country has been recently put in operation at the Portsmouth Plant of the Whitaker-Glessner Company. By this addition the company have considerably increased their production of finished steel and are now in a position to further expand their rapidly growing plant, which normally employs more than five thousand men.

The mill was built by the Morgan Construction Company of Worcester, Mass., and consists of six (6) stands of 18-inch roughing and finishing rolls together with two (2) edging mills, located respectively in front of the first and third roughing passes. Provision is made for drawing loops between each pass when rolling sheet bar and by use of the edging rolls, they are permitted to roll sheet bar with good edges and accurate weight from slabs 12 inches wide and 2½ inches thick to 10-pound bar without having to use tongue and groove passes. The shoes are so arranged that each mill can be lifted off separately and replaced with mills assembled, ready for rolling blooms from 4-inch square to billets 1½-inch square—twisting guides being placed between each alternate pair of rolls.

The capacity of the mill is at present limited in production by the blooming mill but it is capable of producing 40,000 tons of 10-pound sheet bar per month.

Fig. 1 shows the mill assembled for rolling sheet bars. In the upper left-hand corner may be seen the skew approach table which was built by the Wheeling Mold & Foundry Co.—this table is provided with rollers 14 inches in diameter which are set at an angle with the centerline of the table. This arrangement enables the operator to quickly center the blooms on the table ready for the first pass as V grooves are cut in each roller 3 inches deep with sides sloping at 45 degrees. When the bloom is delivered to this table, it clings to the side guard while traveling, but just before it is cropped by the preliminary shear, the table is reversed and the bloom travels laterally across to the center where it drops into the V groove and is ready for the first pass. All of the

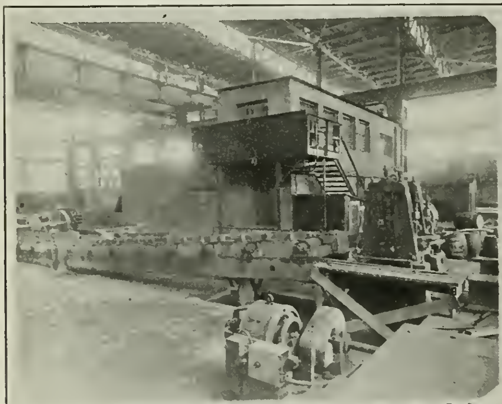
FIG 2

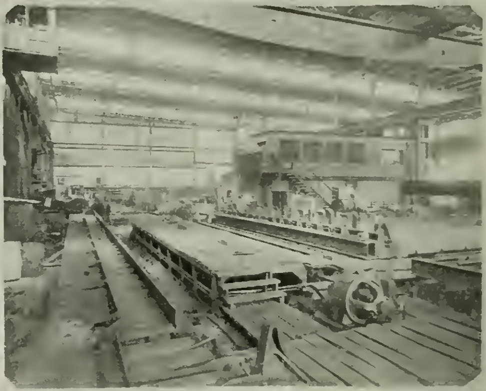
FIG 3

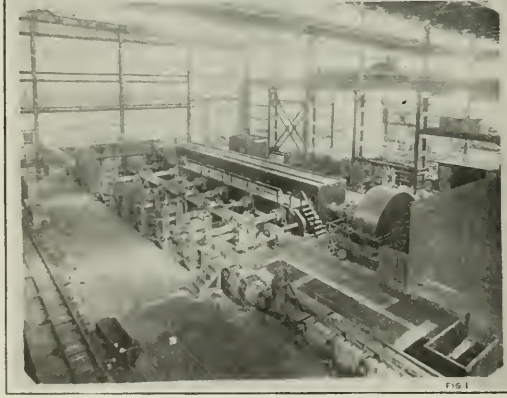
FIG 1

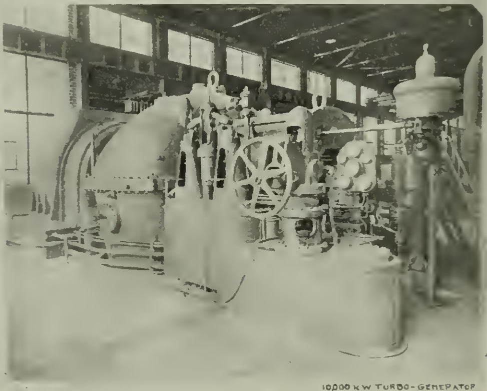
10,000 KW TURBO-GENERATOR

table gears are cut and run in oil—Hyatt bearing being used throughout.

The mill proper is driven by a 5,000 hp, 3 phase, 60 cycle, 2,200 volt motor at 440 rpm, which was built by the General Electric Company of Schenectady, N. Y. Both the motor and the control, is protected by a brick enclosure with a removable roof, which permits the use of overhead mill crane while making repairs.

The main drive was built by the Woodward Machine Company of Wooster, Ohio, and consists of a double helical pinion and gear unit which reduces the speed from 440 to 80 revolutions per minute. The forged steel pinion is cut integral with the shaft while the gear is of cast steel with split hubs held together with shrink rings. The gear cover is of cast iron made tight to permit the gears to run in oil and the bearings are connected with a Bowser Gravity Feed Oiling System, which lubricates all the mill bearings and mill pinions—these being built for oil lubrication only.

In the foreground may be seen an Edward-Carroll flying shear, which operates by steam—adjustment of the shear trip can be made on the shear table so that multiples of any desired length of sheet bar can be cut.

Fig. 2 shows the end of the shear table elevated to deliver sheet bar to the pinch rolls, which, in turn, deliver them to removable bar piler shown in Fig. 3. Here the sheet bars are stacked approximately 24 inches high and then removed by a lifting beam with six (6) hooks attached to the overhead crane, which conveys them to the cooling bed shown in Fig. 4. When rolling billets, the end of the shear approach table is lowered level with the skew assembling table, from which the bar piler has been removed. This table has a capacity of 8000 pounds of 1½-inch billets and is provided with skewed rollers which group the billets of approximately 30 feet 0 inch lengths and delivers them by means of a straight edge to the cooling bed, which was also built by the Morgan Construction Company. This bed is 44 feet 0 inches wide and 80 feet 0 inches long and built of heavy rolled steel sections capped with cast iron wearing plates. Billets are pushed across this bed by means of tilting g-devils placed every 6 feet 0 inch at a speed of 188 feet 0 inch per minute to a piling bin located in the adjoining building in which the billets are weighed and then transferred to storage.

The 18-inch mill building is 103 feet 4 inches wide by 717 feet 0 inch long—in the lower end of which is located the sheet bar shears and picklers, which conveniently serve the furnace aisle of the sheet mill building.

In order to provide power to drive this mill and to take care of contemplated extensions, a 10,000 kw turbo-generator, built by the Westinghouse Electric & Mfg. Co., was installed, together with two (2) Stirling boilers of 823 hp capacity equipped with Westinghouse Electric & Mfg. Co. underfeed stokers. All of the necessary piping was supplied by the American Foundry & Construction Co. of Pittsburgh and the pipe covering by the H. W. Johns-Manville Company.

Calorizing as a Protection for Metal

Recent Developments As Applied to Steel, Copper and Brass—Proper Methods of Use — Materials That Can Be Calorized.

By A. V. FARR,*
Vice President, Calorizing Company of Pittsburgh,
Pittsburgh, Pa.

BESIDES copper, calorizing has been applied to iron, steel, nickel, etc. The resistance to the action of heat has been characteristic of all these applications and today the greatest volume of calorized metal is iron and steel.

When it is considered that the loss of metals due to the action of heat runs into millions of dollars per year in this country, we recognize the importance of a process that reduces this loss. In recognition of his service to the world in inventing a means of preventing oxidation of metals at high temperatures, Mr. Van Aller was awarded the Franklin Institute Medal in November, 1918. Calorizing as practiced today has been considerably modified since Mr. Van Aller's early experiments and the following description is based upon standard methods as practiced under the General Electric Company patent rights.

It should be kept in mind that although calorized metal is more rust-resistant than is either iron or steel, that it serves quite a different purpose than does sherardizing or other galvanizing processes. Galvanizing is one of several means of protecting metals against rust or corrosion at ordinary temperatures, whereas calorizing primarily protects metals against the action of heat.

It is well known that all metals in ordinary usage oxidize rapidly at temperatures higher than dull red. By high temperatures is meant such heat conditions as are to be found in the usual commercial heating operations, such as carbonizing, annealing, baking, boiling, drying, distilling, superheating, etc.

It should be understood that calorizing is a process applied to material already made, and serves the purpose of a protective coat. It is not a cast alloy and consequently there is no difficulty in applying it to thin sections, pipes, forged parts or very small pieces. In considering a surface coating to successfully resist heat the following conditions must be met: (1) the coating should be integral with the core or metal being protected (2) it should be able to withstand abrasion usually encountered in industrial service (3) it should not lessen the structural strength of the metal being protected and (4) it should not act as a heat insulator. Let us see how in calorizing these conditions are met.

To gain a better appreciation of the nature of the coat that constitutes calorizing, let us see how the coat is formed. The process of calorizing as most commonly practiced, consists in placing the material to be calorized in a rotary retort and heating in a reducing atmosphere, the retort being filled with a mixture containing finely divided aluminum. This treatment, conducted at high temperature, thoroughly infuses aluminum into the exposed portion of the metal being treated, so as to form a homogeneous aluminum alloy for a certain depth. This depth ranges from a few thousandths of an inch to the permeation of the entire mass, varying with the duration of the treatment and depending upon the service requirements of the material being processed. From this it is clear that calorizing is not a coating *on* the surface, but is *in* the surface of the material. In some cases where calorized trays are used to hold steel parts being heat-treated, the trays and contents are all quenched in oil or water. Such calorized trays are giving good service without cracking. This is as good an illustration of the cohesion between base metal and calorized coat, as could be desired.

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*Abstract of paper read before the Engineering Society of Western Pennsylvania, June 14, 1921. To be published complete in their proceedings.

The calorized surface is hard, in fact too hard to be readily machined or threaded. It therefore presents an excellent surface to withstand abrasion or wear. It is also much harder for a given furnace heat, such as cherry red, than is iron or steel at the same temperature.

The natural question that comes to mind is, "Why does calorizing protect metals at high temperatures?" The protection is due to the oxide formed by the action of heat on the protecting metal. This oxide, known as alumina, prevents the penetration of oxidizing gases to the metal being protected. The aluminum alloys with the metal, entering into solid solution with it. For this reason, should the outer surface become injured, the protective surface renews itself by forming a new oxide coating as far as the aluminum penetrates.

With reference to the third characteristic of a good protective coat—that it should not lessen the structural strength of the material being protected—let us consider the following:

In the process of calorizing, aluminum alloys with the metal without injury to the base metal. This is due to the fact that the aluminum enters into solid solution with the metal, forming a graded penetration. On the outside is alumina, which is the protective coat; next comes aluminum, which upon exposure to heat oxidizes to alumina or penetrates into the base metal forming more alloy; next is a band of aluminum alloyed with the base metal, which is very hard and which can be converted into the protective coat, should the outer coat be destroyed or worn through; and on the inside is the base metal unchanged except being annealed from the calorized process. This formation is clearly shown in one of the illustrations.

The following are physical tests on calorized steel tubing:

Test No.	Elastic Limit Lbs. Per Sq. In.	Ult. Strength Lbs. Per Sq. In.	Elong. 2 In. Per Cent	Elong. 8 In. Per Cent	Reduction of Area Per Cent
1	29,660	47,150*	...	...	51.6
2	28.750	45,310	30.5	23.0	42.9
3	26,290	49,020†	12.0	...	46.6
4	27,450	46,180	40.5	28.9	40.3
5	24,750	46,400	38.2	27.2	50.2
6	24,720	40,040	46.0	29.6	60.0

From this it is evident that the calorizing process gives results which compare favorably with those obtained by a soft anneal.

The reduction of tensile strength due to calorizing is dependent directly upon the cross-sectional area of the part under consideration. For instance, on a ¼-inch rod, the percentage of cross-section which is affected by calorizing is obviously greater than in a 1-inch rod, so that the effect would show up more markedly on a ¼-inch rod.

What Can Be Calorized.

Iron, steel, copper, nickel, brass and, in fact, most metals can be successfully calorized. Although calorized cast gray iron has frequently given excellent results, it is safer practice to use white metal (white cast iron) or malleable cast iron, owing to the fact that the surfaces of same remain unchanged when subjected to heat, whereas gray cast iron "grows" upon continued exposure to heat. This growth in gray cast iron causes surface cracks to form, through which the oxidizing gases penetrate and attack the inner metal. White cast iron, being lower in carbon content, does not grow on exposure to heat and consequently the calorized (protective coat) is not broken by cracks and the inner metal is fully protected.

Cost of Calorizing.

Compared with other heat resisting processes, calorizing is not expensive. This economy is due to the fact that the calorized product is made up of a relatively inexpensive metal, such as iron or steel. The continuous protective coating of aluminum does not raise the total expense of the material to nearly the extent as would be the case if the product were made entirely of expensive material such as nickel, chrome or cobalt. The heat resisting cast alloys of chrome, nickel and iron in use today are far more expensive.

Because calorizing is ordinarily a surface treating process, the cost is based upon the number of square feet or exposed area. Size, shape and amount of material to be calorized in a given length of time are factors also brought into consideration in determining the cost of calorizing, just as in other heat-treating processes. It is safe to assume that the price of calorizing is materially reduced where a regular and large volume of material is involved.

Various Applications.

Iron, Steel and Metal—Retorts, carbonizing and annealing boxes, soot blower elements, furnace parts, etc. The increased life of calorized parts has been successfully demonstrated in a wide variety of applications and conditions.

Oil and Gas—Pressure still tubes for oil refining, valves, retorts, condenser tubes, etc. This has proved to be one of the largest fields of calorizing owing to the high temperatures encountered and the demand for continuous service without shut down.

Gas Engines—Valves, piston heads for Diesel engines, preheating coils, vaporizers, hot balls for ignition.

Carbon and Coke—Retorts, capsules, pipe and other high temperature parts.

Glass—Calorized metal as a substitute for clay parts in connection with hot molten glass. Parts where calorized metal is needed because it does not throw off streaks of rust as does ordinary untreated iron. Also pipe for conveying molten glass, furnace racks, stay bolts, etc.

Enameling—Furnace parts such as racks and points used to support material being enameled.

Miscellaneous—Oil stove burners, conveying apparatus, stoker parts, roasters, rotary dryers, kiln parts, muffle rolls, seamless drawn steel pots, furnace lining, baffle plates, etc.

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*Punch marks pulled off.

†Broke in grips.

Pyrometer Protection Tubes—Because pyrometers are used in such a wide variety of industries, they are deserving of special mention. The accuracy of a pyrometer depends directly upon the condition of the thermocouple. Unless the thermocouple is properly protected, the readings are inaccurate and the instrument worthless. Calorized pyrometer protection tubes are now sold as standard equipment by the various instrument companies and can be had by specifying them.

Thermocouples—Recent tests conducted on calorizing thermocouples indicate consistently satisfactory results. These thermocuples are used either with or without calorized protection tubes. The increased life of the couple and the assurance of dependable pyrometric readings warrant the assumption that the use of calorized thermocouples is a growing one.

One of the most serious and costly phases of plant operation is the shut-down. Quite frequently this is caused by failure of a part subject to heat action. For example, a retort burns through, a tube in a still blisters badly and starts to leak, a metal support burns through and the material being processed is ruined, a thermocouple becomes badly oxidized and breaks off, throwing the pyrometer readings out; or a host of other sources of failure arise from a similar cause. The economy of calorizing as a factor in insuring continuous plant operation will stand very close scrutiny. On this basis alone the cost of calorizing is frequently the best invested money in a plant.

Color Classification of Blast Furnace Slags

Scientific Investigation on the Nature of the Slag Itself — Color Classification of Slags of Value to Blast Furnace Men.

By WALLACE G. IMHOFF.

PART I.

1. Introduction.

BLAST furnace slag investigations have been conducted mainly from the commercial standpoint of utilization of blast furnace slags. Thousands of tons of slag are made annually as a by-product in the manufacture of pig iron, but only a small percentage of the total amount produced is reclaimed. Some of the most important uses that have been made of slag are as a foundation for paved streets (1), for railway ballasting (2), paving brick (3), concrete (4), and road making (5).

Scientific investigations on the nature of slag itself have been very limited. There are at least two reasons for this fact, namely: first, there are very few men thoroughly familiar with both the practical and theoretical side of blast furnace operation, and second, scientific investigations on slags to be of praccital value must be made at the blast furnace itself and under the conditions present when slag is formed.

The characteristics of blast furnace slags were thoroughly understood by Mr. J. E. Johnson, Jr. (6). His articles published in the Metallurgical and Chemical Engineering Magazine and his book, "Blast Furnace Construction in America" (2), show that he was an authority on blast furnace operation and construction.

Other extremely interesting and valuable investigations have been made on the viscosity of slags by the United States Bureau of Mines (8). Numerous articles have appeared on slags, but very little work has been done in discovering the nature of slag, the features controlling its composition, how the individual components of the slag behave under different conditions, slag types, slag color, and many other interesting characteristics. In other words, very little has been done in the investigation of slag itself.

The writer, about ten years ago, decided to carry on research investigations on the blast furnace while employed as stove tender, water tender, and blower on furnaces supplying pig iron for the daily market. After about three years of careful observations, in 1913 a table was worked out somewhat like shorthand and this code was used in making permanent records of blast furnace casts for the next four years. Photographs were made of the iron and slag to illustrate special features of interest.

Some of these investigations were described in a number of technical articles published in 1916 and 1917 (9), but, due to the war, the work was interrupted. These articles described various slag characteristics and illustrated clearly how they could be identified. In addition to careful observations on slag other features that effect the slag composition were investigated, such as extra coke (10), hearth temperature (11), stock, wind, fusion zone, top heat, and method of charging, all of which help to determine the final composition of the slag.

A glance over the field covered in the articles so far published show that the investigations cover a field where there are wonderful possibilities still untouched. This paper has been written for two purposes:

1. To furnish scientific data on "Molten Magmas" to the geologist.

2. To furnish the blast furnace man with a complete table of "Color Classification of Blast Furnace Slags."

This, I believe, is the first attempt that has ever been made to scientifically classify blast furnace slags. It, no doubt, has many weak points, but it is hoped as time goes on and other investigators add new data, that eventually the classification will be extremely useful to all practical blast furnace men.

2. Blast Furnace Slag as a Molten Magma.

a. The Nature of Blast Furnace Slag.

Blast furnace slags may be considered as very flexible molten magmas, ever changing in composition and produced under continually changing conditions of temperature and pressure. Ore, coke, and limestone are charged in at the top of the furnace, and iron and slag are drawn out at the bottom. Blast furnace operation is the establishing of an equilibrium from a mass of variables producing in the final stage slag from the gangue of the ore, coke, and stone, and pig iron from the ores.

The slags are sometimes thin and fluid, sometimes thick and viscous, sometimes extremely hot, at other times extremely cold, and continually varying in composition. In the furnace they are at an extremely high temperature and under great pressure. Often, in fact, always, they contain some gases in solution and in a great many ways are similar to molten magmas found at different places on the earth.

That other investigators have noticed a similarity between slags and lavas is well illustrated by various references to slags in rock text books. Pirsson calls attention to the "slaggy" structure of a basaltic lava (12) and the two types of rock samples in the illustration are common slag samples seen on the blast furnace.

b. The Components of Blast Furnace Slag.

The average blast furnace slag is composed of silica, alumina, lime, magnesia, sulphur, iron, and manganese. In the past it has been considered simply as a slag, and the behavior of its components was studied mainly from the standpoint of fluxing out the impurities of the ore, coke, and stone, and thus producing a good grade of pig iron. The discussion herein submitted is from an entirely different viewpoint.

The writer has not been able to find any literature on blast furnace slags from the standpoint of a molten magma. Therefore, it is difficult to do more than try to outline some fundamental features which serve to explain some of the characteristics of slags, and thus in an indirect way lead to better furnace operation.

To begin with, there are a few fundamental known things, and from these we can at least derive material that more or less satisfactorily explains many other features. The first principle, which stands out prominenty, is that temperature and slag composition are inseparable.

After carefully studying a large number of slags the idea developed that a slag is only a molten magma, and hence no doubt would exhibit some, or most of the characteristics of magmas. Each step in the investigations proved the theory proposed entirely possible so that the whole presents an excellent means of blast furnace control.

The first thing to consider then is the characteristics of the components that make up the slag, their color, their melting points, and their behavior under various changes of temperature and pressure.

These characteristics may be summarized in the following table:

Silica	Colorless	(SiO_2)	1600–1750° C. (13)
Alumina	Colorless	(Al_2O_3)	2050° C. (14)
Lime	White	(CaO)	2570° C. (15)
Magnesia	White	(MgO)	2800° C. (15)
Iron Oxide	Black	(FeO)	1419° C. (16)
Sulphur	Pale Yellow	(S)	120° C. (17)
Manganous Oxide	Olive Green	(MnO)	White Heat (18)

c. The Variation and Mineral Composition of Magmas.

Kemp (14) states that the term magma is now generally employed for the molten masses of igneous rocks before they have crystallized. He also says (20): "Of recent years we have come to regard molten magmas as essentially solutions of some compounds in others, and to appreciate that solutions do not cease to be such, even when the temperature is very high." Practically the same opinion is expressed by Chamberlin and Salisbury (21), which is as follows: "A molten magma is not to be viewed simply as a fused substance, but rather as a solution of one silicate in another, or as a solution of several silicates in one another mutually. The high temperature is to be regarded merely as a condition prerequisite to solution, or as the condition of fusion of some one constituent which then dissolves the others."

Clark (22), Pirsson (23), Leith and Van Hise (24), and many other geologists have described molten magmas and the writer has derived material for the present discussion from all these authors.

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(2) Blast furnace slag for railway ballasting. il Plan Engineer. 120:395-6 0 22. 1915.

(3) Manufacture of paving brick from furnace slag. Eng. Rec. 68:24. August 30, 1913.

Utilization of blast furnace slag for brick. Iron Age. 91:813. April 3, 1913.

(4) Blast furnace slag in concrete. W. A. Aiken. Iron Trade Review. 55:31-2. July 2, 1914.

(5) Utilization of iron and steel works slag. E. C. Brown. Eng. Soc. W. Pa. 31:884-96. January, 1916.

(6) The Operation of the Blast Furnace. Slags. By J. E. Johnson, Jr., Met. and Chem. Eng. April 1, 1916.

(7) Blast Furnace Construction in America. By J. E. Johnson, Jr. McGraw-Hill Book Company, Inc., 239 West Thirty-ninth street, New York, N. Y. 1917.

(8) Method of Measuring the Viscosity of Blast Furnace Slag at High Temperature. A. L. Field. U. S. Bureau of Mines. Tech. Paper 157. January 27, 1916.

(9) Conditions and Causes of Iron in Slags. By Wallace G. Imhoff. Blast Furnace and Steel Plant. August, 1916.

Conditions and Causes of Iron in Slags. II. By Wallace G. Imhoff. Blast Furnace and Steel Plant. September, 1916.

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Some Causes of Colors in Furnace Slags. By Wallace G. Imhoff. Blast Furnace and Steel Plant. February, 1917.

Types of Different Blast Furnace Slags. By Wallace G. Imhoff. Blast Furnace and Steel Plant. March, 1917.

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Lime as a Component of Furnace Slag. By Wallace G. Imhoff. Blast Furnace and Steel Plant September, 1917.

(10) Uses of Extra Coke on the Blast Furnace. By Wallace G. Imhoff. Blast Furnace and Steel Plant. January, 1916.

(11) How Tuyeres Indicate Furnace Conditions. By Wallace G. Imhoff. Blast Furnace and Steel Plant. July, 1916.

(12) Rocks and Rock Minerals. By Louis V. Pirsson. Plate 22. John Wiley and Sons, New York, N. Y.

(13) The Data of Geochemistry. By Frank Wigglesworth Clark. U. S. G. S. Bull. 695, p. 288.

(14) The Data of Geochemistry. By Frank Wigglesworth Clark. U. S. G. S. Bull. 695, p. 332, and Jour. Washington Acad. Sci., vol. 3, 1913, p. 318. C. W. Kanolt.

(To be continued)

Deterioration of Coking Property of Coal

Experiments Described Which Were Made to Get More Definite Information Regarding Deterioration Effects of Different Degrees of Heating and to Determine a Rapid, Accurate Quantitative Test.

By WM. SEYMOUR.
Algoma Steel Corporation, Ltd.

THE deterioration of coal in storage has received much consideration by many but most of the work done has been with reference to the heating value and slight consideration has been given to coking property. The Algoma Steel Corporation, located at Sault Ste. Marie, Ont., Canada, must stock the winter's supply of coal (about 6 months' supply) in order to take advantage of water transportation from Ohio ports. The fact that heating, even not enough to start fires, caused deterioration of the coking property has been known for a considerable time and steps have been taken each season to keep this heating as small as possible by cross-cutting the pile, transferring the coal from the hot places, etc.

The objects of the experiments here described were: to get more definite information regarding the deterioration effects of different degrees of heating and to determine a rapid, accurate, quantitative test that applied to any sample of coal going to the ovens, would tell to what extent the coking property had depreciated.

The coals used are Cannelton, from the Cannelton Coal & Coke Co.'s mines in West Virginia, and Pocahontas, from the Superior mines of the same company in the same state.

Ultimate analyses on various samples, given in Table 1, as might be expected, show that the heated

	Ultimate analyses						Ash free basis					
	Percent C	Percent H_2	Percent N_2	Percent O_2	Percent S	Percent Ash	C Percent	H_2 Percent	N_2 Percent	C_2 Percent	S Percent	H/O
1.	78.18	5.03	1.48	7.08	1.31	6.92	84.00	5.40	1.59	7.61	1.40	71.0
2.	76.08	4.99	1.40	9.51	1.37	6.64	81.49	5.34	1.50	10.19	1.47	52.4
3.	74.99	4.88	1.40	10.72	1.31	6.70	80.38	5.23	1.50	11.49	1.40	45.5
4.	73.83	4.66	1.37	12.23	1.35	6.56	79.01	4.99	1.47	13.09	1.44	38.1
5.	71.48	4.50	1.32	15.02	1.32	6.42	76.45	4.81	1.41	16.05	1.35	30.0
6.	68.31	4.16	1.23	18.79	1.41	6.20	72.82	4.44	1.30	20.02	1.41	22.1

Table 1—Ultimate Analyses of Cannelton Coal.

1. Cannelton coal from SS. Roberts (fresh).
2. Cannelton from large stock pile.
3. From small piles left after cleaning up.
4. From heated stock pile.

							Ash Free Basis				
	C Percent	H_2 Percent	N_2 Percent	O_2 Percent	S Percent	Ash	C Percent	H_2 Percent	N_2 Percent	O_2 Percent	S Percent
1.	74.83	4.83	1.53	7.93	1.08	9.80	82.96	5.36	1.69	8.79	1.20
2.	74.28	4.33	0.37	11.27	1.15	8.60	81.27	4.74	0.41	12.33	1.25
3.	74.72	4.55	1.44	10.87	1.22	7.20	80.52	4.90	1.55	11.72	1.31
4.	73.90	4.44	0.10	10.02	0.74	10.80	82.85	4.99	0.11	11.24	0.81

Table 2—Heated Coal From Stock Pile.

	Sieve Test		Approximate analyses			Ash Free Basis	
		Percent	Ash Percent	Volatile Percent	Fixed carbon Percent	Volatile Percent	Fixed carbon Percent
1.	On ¼-in. mesh	49.6	9.96	32.50	57.54	36.10	63.90
2.	On ⅛-in. mesh	19.1	9.45	32.80	57.75	36.22	63.78
3.	Thru ⅓-in. mesh	31.3	12.80	30.90	56.30	35.44	64.56
		100.0					
4.	On 20 mesh	13.75	10.56	32.10	57.34	35.89	64.11
5.	On 40 mesh	7.75	12.30	30.00	57.70	34.21	65.79
6.	On 60 mesh	4.00	14.22	28.90	56.88	33.69	66.31
7.	On 80 mesh	0.25	15.10				
8.	On 100 mesh	1.25	15.00	28.50	56.50	33.53	64.47
9.	Thru 100 mesh	4.75	15.85	28.50	55.65	33.87	66.13

Ultimate Analyses.

	C Percent	H_2 Percent	N_2 Percent	O_2 Percent	S Percent	Ash Percent	C Percent	H_2 Percent	N_2 Percent	O_2 Percent	S Percent	$\frac{H}{O}$ ratio
1.	74.25	5.00	1.50	8.08	1.37	9.80	82.33	5.54	1.66	8.96	1.52	61.8
2.	74.00	5.00	1.44	9.21	1.15	9.20	81.51	5.51	1.58	10.14	1.26	54.3
3.	71.72	4.27	1.37	9.33	0.91	12.40	81.87	4.88	1.56	10.65	1.04	45.8
9.	66.00	3.37	1.17	13.01	1.20	15.25	77.88	3.97	1.38	15.35	1.42	26.0

coal absorbed oxygen.

Because a much larger per cent of Cannelton is used the preliminary work was confined to the high volatile coal.

The first experiment was to select a sample of coal from the stock pile that we were fairly sure had been heated sufficiently to cause considerable deterioration. The sample was taken from a small ridge that had been left by the bucket when cleaning up. This ridge was about 4 feet at the deepest part and a thermometer inserted about 4 inches in the pile showed a temperature of 80 degrees C.

The sample as taken was screened and per cent of each size determined. Approximate analyses were made of each size and ultimate analyses of, sample 1, (on ¼-inch mesh); sample 2, (on ⅛-inch mesh); sample 3, (thru ⅛-inch mesh); and sample 9, (thru 100 mesh).

These results are given in Table 2.

The "buttons" resulting from the standard volatile test were carefully observed as to coking property. We have adopted the following descriptions of these buttons as standard and will hereafter refer to them by number.

Coking property No. 1: good coke, swelling to two or three times the original volume of the coal, hard and with a metallic luster.

Coking property No. 2: good coke, slight swelling, quite hard, metallic luster.

Coking property No. 3: fair coke, no swelling, quite firm, slight metallic luster.

Coking property No. 4: poor coke, no swelling, maintains "button" shape, soft, black, no luster.

Coking property No. 5: coking property destroyed, falls apart upon removing from crucible, black, some adhesion, similar to fine wet sand pressed in crucible with finger then dumped out.

Coking property No. 6: remains as black powder.

The resulting buttons from the screened samples of stock coal are described as follows:

No. 1,	on ¼-inch mesh,	No. 2 coking property.
No. 2,	on ⅛-inch mesh,	No. 2
No. 3,	thru ⅛-inch mesh,	No. 4
No. 4,	on 20-inch mesh,	No. 3
No. 5,	on 40-inch mesh,	No. 5
No. 6,	on 60-inch mesh,	No. 6
No. 7,	on 80-inch mesh,	not enough for test.
No. 8,	on 100-inch mesh,	No. 6 coking property.
No. 9,	thru 100-inch mesh,	No. 6

These samples of coal have been retained and, together with the preceding results, have been used for reference and for comparison with the remainder of the work, which deals chiefly with artificially heated coal.

The first series of tests were made to determine the deterioration of coking quality of coal that had been subjected to various degrees of heat for varying lengths of time. A large sample of fresh coal was placed in an air-tight container and all of the following experiments have been made on portions of this sample.

The method of procedure was as follows, the coal is ground so as to pass a 100 mesh screen, 5 gm. samples are weighed into porcelain crucible lids and spread out with a spatula so as to expose a maximum amount of surface, the samples are then put into an air bath and a constant temperature maintained for the desired length of time.

Five tests were run at temperatures from 100 to 200 degrees C. by increments of 25 degrees. No. 1, heated from 0 to 5 hour at 200 degrees C., gave the following results:

No. of Sample	Time of heating hours	Increase in weight %	Coking property number
1	0	0	1
2	1	2.65	6
3	2	3.74	6
4	3	3.61	6
5	4	3.92	6
6	5	4.08	6

No. 2, heated from 0 to 4 hours at 175 degrees C., gave the following results:

No. of Sample	Time of heating hours	Increase in weight %	Coking property number
1	0	0	1
2	1	1.31	4
3	2	1.53	5
4	3	1.72	6
5	4	3.42	6

No. 3, heated from 0 to 5 hours at 150 degrees C., gave the following results:

No. of Sample	Time of heating hours	Increase in weight %	Coking property number
1	0	0	1
2	1	.22	3
3	2	.91	4
4	3	1.46	5
5	4	1.98	5
6	5	2.83	6

No. 4, heated from 0 to 12 hours at 125 degrees C., gave the following results:

No. of Sample	Time of heating hours	Increase in weight %	Coking property number
1	0	0	1
2	2	2.02	4
3	4	1.96	4
4	6	2.76	4
5	8	3.00	5
6	10	3.76	5
7	12	5.10	5

No. 5, heated from 0 to 11 days at 100 degrees C., gave the following results:

No. of Sample	Time of heating hours	Increase in weight %	Coking property number
1	0	0	1
2	2	1.94	2
3	4	3.14	3
4	6	3.90	4
5	11	4.30	5
6	11	7.82	

Note: No. 6 was a special test run for 11 days at 125 degrees C.

In addition to the button tests and increase in weight an ultimate analysis was made on each sample.

This test is worthy of careful consideration. It shows very clearly the decided increase in oxygen. The hydrogen-oxygen ratio drops rapidly, at 4 days being below the point which is considered necessary by White for a good coking coal (Effect of Oxygen in Coal, by David White, Bureau of Mines Bulletin 29, 1911).

The results of these tests show conclusively that even with a temperature as low as as 100 degrees C., the coking property will, under favorable conditions, be destroyed in a short time. Conditions in the storage pile differ from those of the tests in that: (1) Much of the coal is lump, (2) air does not have free access to all of the coal, and (3) the storage pile has a large amount of water vapor while the air bath of the tests was practically free from vapor. While further work along the above lines would undoubtedly be of interest and value, it was decided at this point to work on the second objective, namely the determination of a rapid, accurate, quantitative test to determine the percentage of deterioration.

Consideration of the ultimate analyses indicates that the oxygen content or the hydrogen-oxygen ratio might, upon study, give accurate information as to deterioration. The objections to any method based on ultimate analysis are: (1) the expensive apparatus necessary, (2) the time required, (3) the skilled manipulation necessary and (4) necessity for careful checking.

Many attempts were made to discover a test that would cover all requirements. Most of them were based on the theory that if the maximum amount of oxygen that a sample of fresh coal would absorb could be determined, this determination applied to a given sample would show to what extent it had absorbed oxygen before the test was applied and, consequently, the amount of deterioration. Some of the experiments made gave no results, others were rejected on account of insufficient accuracy. Of the latter, oxidation with nitric acid was one of the most promising. One gram of coal, ground to pass through a 100-mesh screen, was weighed into a porcelain crucible, 2 cu. cm. of concentrated HNO_3 run in carefully from a burette, thoroughly stirred with a glass rod, allowed to stand 10 minutes, diluted with cold water, filtered, washed, filtrate titrated, and amount of acid used calculated. A large number of tests were made in this manner and checked up fairly well with coking tests, etc., but the method was finally rejected as not sufficiently accurate.

In some of the experiments with coal, it was noticed that treatment of heated coal with caustic potash or ammonia gave a liquor with a brownish color, the depth of color apparently depending on the degree of deterioration of coking property of the coal. It was also noticed that fresh coal, similarly treated, gave no color. In order to prove that this color is not due to iron in the coal, the sample was washed with HCl, then with water, and treated with caustic; the same brownish color remained in the filtrate. We then developed a color comparison test and all our work so far warrants the assumption that this method fills the requirements of our second objective.

The method of procedure is as follows: Sample (as taken, not dried. If moisture is to be considered separate determination must be made for same) is ground to pass through 100-mesh sieve. Five (5) grams is weighed into a flash or breaker, 100 cu. cm. of dilute (1 part acid to 10 parts water) hydrochloric acid added, mixed thoroughly, boiled a few minutes and filtered on an asbestos plug with suction. Residue is washed with hot water and filtrate discarded. Rinse filtering flask thoroughly replace and wash residue remaining on asbestos plug with boiling normal caustic soda, about six washings (enough to wash out color thoroughly) totaling about 50 cu. cm. The filtrate, if colored, is diluted to 50 cu. cm. and compared in Nessler tubes with a standard color. In comparing the colors the standard is diluted so as to match the color being tested and per cent of dilution observed.

It was necessary to establish a standard. For this purpose sample No. 6 of the heated coal from stock pile, which was the portion remaining on a 60-mesh screen, was selected and arbitrarily assumed to be 100 per cent non-coking. Efforts have been made to duplicate this color with a known mixture but they have not been successful. It has been reproduced by heating fresh coal, ground to pass a 100-mesh screen, in an air bath at 150 degrees C. for a length of time sufficient to make it non-coking when tested in a crucible. Without doubt a tintometer could be made up to serve the purpose.

For eight months, April, 1920 to November, 1920, inclusive, daily tests have been run on the mixed coal to the ovens and the results of these tests have been plotted together with the daily coke per ton iron on the blast furnaces. Considering the other factors entering into blast furnace operation the similarity of these curves is remarkable.

Consideration of the increased coke per ton iron and the loss of by-products at the ovens shows that the financial loss due to oxidized coal may be enormous.

How may this loss be prevented? Much has been written upon the stocking of coal to prevent segregation, etc. and care in this regard will undoubtedly effect a considerable saving. But careful consideration of the sample of heated coal from stock makes it appear that the loss might be eliminated by screening the coal at the stock pile, stocking the lump and using the fines as soon as possible.

These experiments show the importance of getting coal into the ovens before it has undergone any chemical changes due to exposure to the atmosphere and it might be possible that, with the poor coking coals, it would pay to locate the ovens at the mines.

LATE DEVELOPMENTS IN THE BASSET DIRECT STEEL PROCESS.

The latest developments in the Basset direct process for steel in France are recounted by the French correspondent of the London *Ironmonger,* in its issue for May 7, as follows:

The experimental stage in Lucien Basset's process for the production of iron, steel and pig iron direct from ore in the rotary furnace is said consisting of twelve 250-ton furnaces, on the edge of the iron mines of Normandy, capable of producing 3,000 tons of metal per day, will begin to be constructed in the course of a month. The cost of production, it is claimed, will be only 110 francs per ton, a figure which seems incredible in view of the fact that ore alone today is between 20 and 30 francs per ton, and the cheapest coal obtainable from 90 to 100 francs per ton. M. Basset also states that each furnace will cos tonly 2,500,000 francs to erect, compared with the 42,000,000 francs required for the erection of blast furnaces or an open-hearth plant of like capacity. The erection of the plant, he says, has been decided upon after the success obtained recently at Dennemont, near Mantes, first with 25-ton and then with 100-ton furnaces, in which rail-quality steel has been successfully produced. M. Basset's unwillingness to permit inspection of his plant throughout his experiments has, not unnaturally, created a good deal of skepticism on the Continent, and the claims made for his process are not yet taken very seriously by steelmakers. Should his promises be fulfilled and steel be placed on the market at a price which is even less than that ruling in pre-war days, and at only a quarter of the present quotation, a revolution will indeed be brought about in metallurgy.

Analysis of Wholesale Electric Costs

Graphic Charts Which Facilitate the Analysis of Light and Power Costs.

By F. M. VAN DEVENTER.

SYNOPSIS: *The preceding article presented a graphic chart for the solution of costs and unit rates for electric power purchased under Duquesne Light Company's wholesale power schedule "F." The present article presents a similar chart based upon the West Penn Power Company's wholesale power schedule "J." The article contains an explanation of the chart and of one of its principal uses. The third article will embody a general consideration of the "demand plus energy" system of rates, and an analysis of the consumers' power conditions which affect the cost of the service.*

ARTICLE II.

WHEN power was purchased under a unit rate per kwh, the rate being a definitely fixed quantity for each user, depending upon whether he were a small domestic consumer or a purchaser of power in "wholesale lots," it was an easy matter to check the monthly charge for power, by merely multiplying the quantity of energy metered by the unit rate. Similarly an estimator or engineer who was confronted with a problem which involved the power charge for operating a piece of proposed equipment knew what the unit energy rate would be, without any calculation.

The present-day 'demand plus energy" schedules, however, entail considerable complication, as the unit rate to a particular consumer changes from one month to the next, depending upon the nature of the load curve; and a more or less extensive calculation must be made to check a power bill or to determine the unit rate under any assumed condition.

The West Penn Power Company's schedule "J" for wholesale light and power is a good example of this type of rate. The several paragraphs which fix the cost service are essentially as follows:

LARGE POWER RATE.

(Available for Alternating Current Service.)

SCHEDULE "J."

RATE.

For the kilowatt hours of electric energy delivered per month up to the amount corresponding to seventy (70) hours use of consumer's demand, six (6) cents gross per kilowatt hour.

For remainder of electric energy delivered during same month, one and one-quarter (1¼) cents gross per kilowatt hour.

CONSUMER'S DEMAND.

Consumer's demand will be based upon the significant peak created at each service connection and will be determined for each class of service by application of the provisions hereinafter contained.

The significant peak will be the amount of power equivalent to the maximum average kilovolt amperes drawn for a period of five consecutive minutes during any billing month, plus fifty (50) per centum of that part of any single operating peak created during the same billing month which is in excess of one hundred fifty (150) per centum of such maximum average for a five minute period.

The significant peak may be determined at option of producer, as follows:

a. By calculation from Table No. 1 constituting a part of this Schedule.

b. By calculation from a registration of ampere measuring devices only, it being assumed that the nominal voltage is constant.

c. By registration in kilowatts; for which purpose indicating instruments showing average conditions may be used.

d. By concurrent measurement or registration of the kilowatts and wattless component of the electric energy drawn.

e. By concurrent measurement or registration of ampere and voltage measuring devices.

*(Method c. is customarily used by this company. A kw record is obtained from a curve-drawing meter; the significant (5-minute) peak and the instantaneous peak are observed from the curve, and the demand thus obtained is corrected for power factor to give the kv-a demand.)

Notes:

. . . .

b. In determining the significant peak any five-minute average or single operating peak created during off peak hours, as hereinafter defined, will be taken at fifty (50) per centum of the actual amount of such peak or peaks; provided, that consumer shall submit proof satisfactory to producer of the time such peak or peaks were created.

CLASSES OF SERVICE.

a. General services entitles consumer to power during all hours and consumer's demand will be the full amount of the significant peak calculated or measured in kilovolt-amperes, except when consumer so operates as to earn line regulation discount, in which event the significant peak will be calculated or measured in kilowatts.

b. Off peak service entitles consumer to power during off hours only and consumer's demand will be twenty-five (25) per centum of the amount of the significant peak calculated or measured in kilovolt-amperes. In consideration of the low charge for this class of service, consumer will not be entitled under any circumstances to power except during off peak hours and producer may at its option cut off the energy during all other hours.

OFF PEAK HOURS.

Off peak hours, as used herein, are from 5:00 P. M. until 7:00 A. M. daily, from 12:00 noon Saturday until 7:00 A. M. Monday; and all day holidays generally observed.

MINIMUM CONSUMER'S DEMAND.

Minimum consumer's demand for each service connection will be one (1) KV-A.

To compensate for the capacity required to supply varying demands, the minimum consumer's demand, for any month will be fifty (50) per centum of the highest demand, established for any month within the eleven months last preceding, except in case of permanent material reduction in consumer's installation; provided, however, if consumer has a number of service connections so located that the charges for service delivered thereto may be aggregated, as hereinafter provided under paragraph "Term Discounts," the aggregate demand, i. e., the sum of the consumer's demands for each service connection, will be used in the application of this provision and the minimum aggregate demand will be seventy-five (75) per centum of the highest aggregate demand for the same service connections established for any month within the eleven months last preceding; and the primary rate of six (6) cents per kilowatt hour shall apply to the aggregate net amount of energy consumed up to an amount equal to seventy (70) hours use of seventy-five (75) per centum of such maximum aggregate demand.

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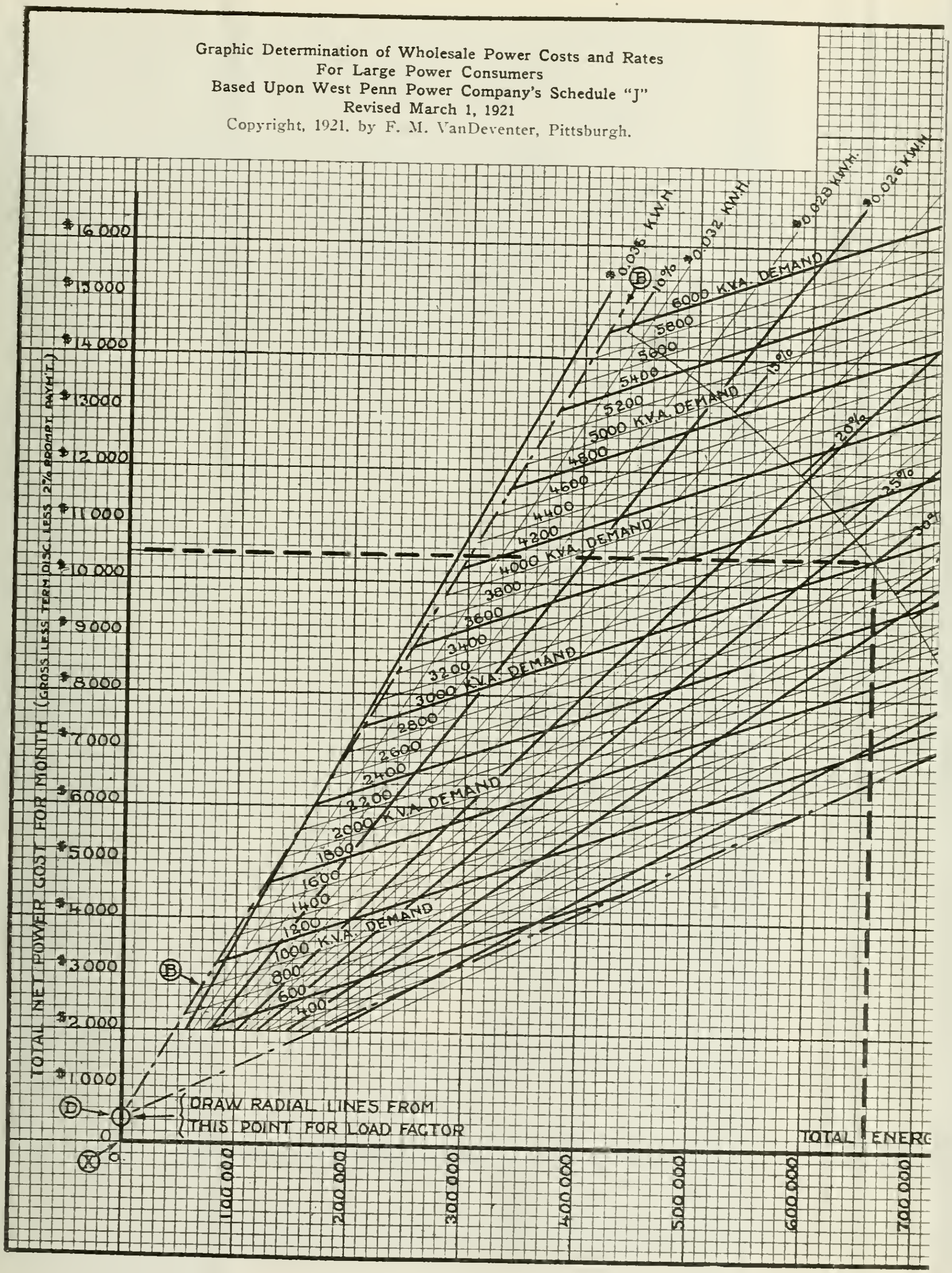
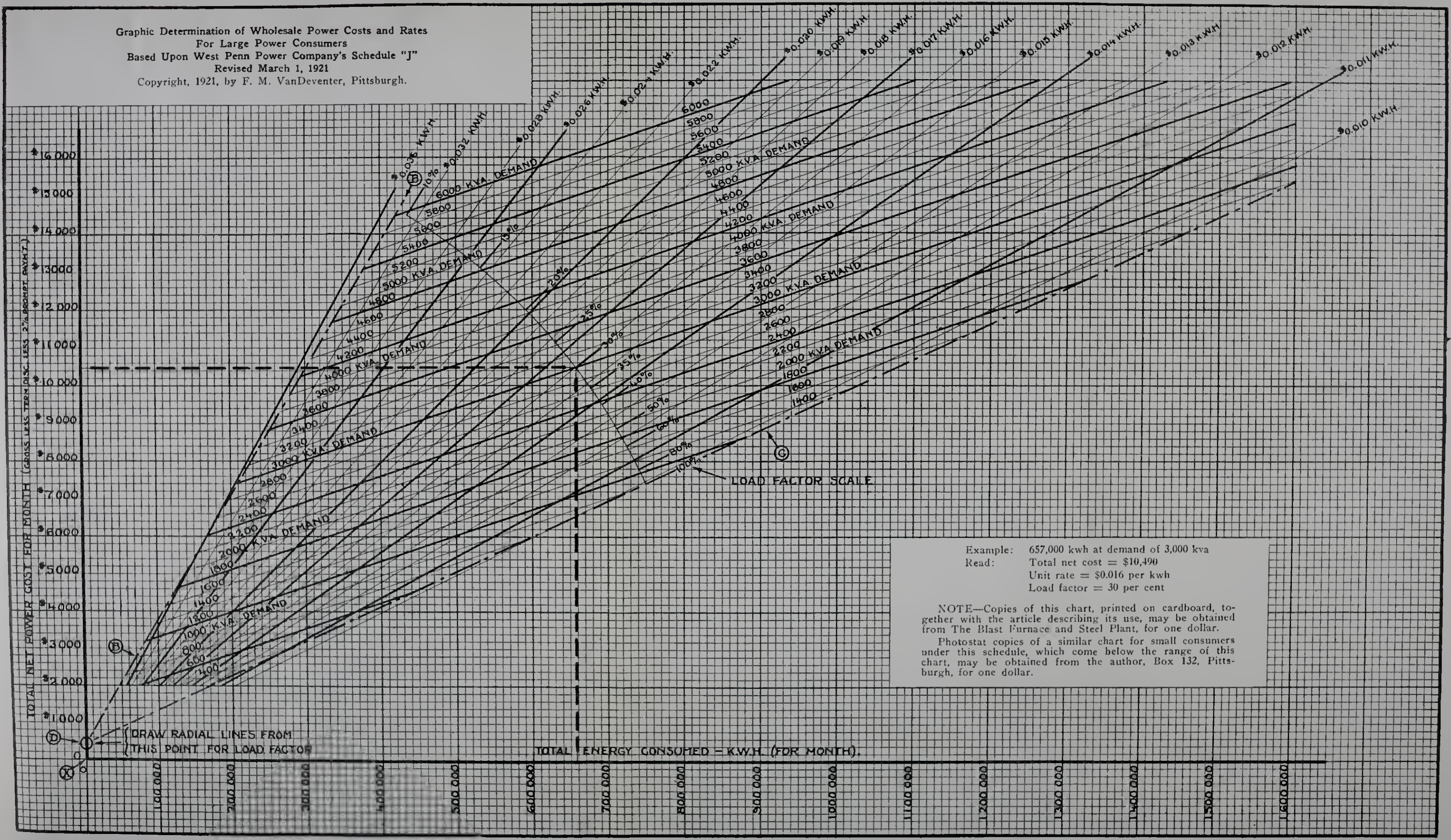
*Author's note.

Graphic Determination of Wholesale Power Costs and Rates
For Large Power Consumers
Based Upon West Penn Power Company's Schedule "J"
Revised March 1, 1921

Copyright, 1921, by F. M. VanDeventer, Pittsburgh.





Graphic Determination of Wholesale Power Costs and Rates
For Large Power Consumers
Based Upon West Penn Power Company's Schedule "J"
Revised March 1, 1921

Copyright, 1921, by F. M. VanDeventer, Pittsburgh.

Example: 657,000 kwh at demand of 3,000 kva
Read: Total net cost = $10,490
Unit rate = $0.016 per kwh
Load factor = 30 per cent

NOTE—Copies of this chart, printed on cardboard, together with the article describing its use, may be obtained from The Blast Furnace and Steel Plant, for one dollar.

Photostat copies of a similar chart for small consumers under this schedule, which come below the range of this chart, may be obtained from the author, Box 132, Pittsburgh, for one dollar.

SYSTEM VOLTAGE DISCOUNTS.

(a) Where electric service is furnished by producer from a distributing system having a voltage between one thousand (1,000) and fifteen thousand (15,000) volts and consumer purchases electric service at the system voltage, thereby relieving producer from transforming obligation and expense, a deduction of five (5) per centum of the total kilowatt hours of electric energy delivered at such system voltage will be made before calculating charge to consumer.

(b) Where electric service is furnished by producer from a distributing system having a voltage above fifteen thousand (15,000) volts and consumer purchases electric service at the system voltage, thereby relieving producer from transforming obligation and expense, a deduction of ten (10) per centum of the total kilowatt hours of electric energy delivered at such system voltage will be made before calculating charge to consumer; provided, that for reasons of safety producer may refuse to supply electric service from or to allow service connections to be made to systems having voltage of fifteen thousand (15,000) volts or more.

LINE REGULATION DISCOUNTS.

(Not applicable to off-peak service.)

a. Where consumer constantly maintains leading power factor of ninety (90) or less per centum, at any service connection, a deduction of five (5) per centum of the total kilowatt hours of electric energy delivered by such service connection will be made before calculating charge to consumer.

b. Where consumer, during all hours of operation, by the use of automatically regulated synchronous apparatus of sufficient capacity to maintain a leading power-factor of ninety (90) per centum at any service connection under normal operating conditions, regulates the voltage of producer's service to the fullest capacity of such apparatus, a deduction of five (5) per centum of the total kilowatt hours of electric energy delivered by such service connection, will be made before calculating charge to consumer.

TERM DISCOUNTS.

Where electric service is furnished consumer under guarantee to take service for a term of one (1) year or longer in accordance with rules and regulations of producer, block discounts shown below will be allowed for each metering point on energy charges calculated from above rates; provided, however, if consumer has a number of service connections into one premises or operation, or which could be economically connected by consumer's own transmission line, charges for electric service delivered under this schedule to all of such service connections shall be aggegated and such block discounts applied to the total sum of energy charges of the separate service connections.

BLOCK DISCOUNTS.

(To be calculated on the basis of billing month.)

First $100.00—Net
Next 100.00— 2½ per cent
Next 100.00— 7½ per cent
Next 100.00—10 per cent
Next 100.00—12 per cent
Next 100.00—15 per cent
Next $200.00—18 per cent
Next 200.00—21 per cent
Next 200.00—25 per cent
Next 200.00—29 per cent
Next 200.00—33 per cent
Next 200.00—38 per cent

All amounts in excess of $1,800.00—43 per cent.

MINIMUM CHARGES.

The minimum monthly gross charge to be paid by consumer will be an amount equal to twenty-five (25) hours' use of maximum consumer's demand at any time established subject to the following provisions:

a. A measured consumer's demand will take precedence over that previously established by application of Table No. 1.

b. The minimum monthly charge will not be less than an amount equal to twenty-five (25) hours' use of:

1. Fifty (50) per centum of the kw capacity specified in the proposal covering the service connection effective after producer has installed its facilities necessary to furnish electric service.
2. The rated capacity of consumer's largest connected motor or piece of apparatus.
3. The rated capacity of the transforming apparatus installed on the service connection when the service required is of such character that excess transforming capacity is necessary to supply instantaneous or momentary operating peaks.

. . . .

In calculating all minimum charges the gross rate of six (6) cents per kilowatt hour will be used subject to prompt payment discount only; term discounts are not applicable to minimum charges.

PROMPT PAYMENT DISCOUNT.

A discount of two (2) per centum will be allowed on the monthly bill if paid in full on or before the tenth (10) day after that on which bill is rendered.

In determining amount of any discount only two decimal places will be employed in case of money and the nearest unit in case of energy.

RIDER TO SCHEDULE "J" FOR LIMITED SERVICE.

Limited service entitles consumer to power during all hours, except for such temporary periods as may be prescribed by producer, by reason of reduced or insufficient capacity of producer's facilities, in accordance with the terms and conditions hereinafter contained. The supply of limited service grants a priority for continuous power service, except in cases of emergency, to consumers supplied with general service under Schedule "J," the provisions of which shall obtain except as they are modified by the terms and conditions of this rider and of the proposal for limited service.

(a) Limited service is available only to consumers creating in normal operation significant peaks of not less than 500 kw, and it will be supplied and significant peak and energy will be metered only at system voltages above 15,000 volts.

(b) Consumer's demand will be seventy (70) per centum of the amount of significant peak, calculated or measured in kilovolt-amperes as provided in Schedule "J;" provided, however, that consumer's demand shall be fifty-eight (58) per centum of such significant peak for any billing month during which producer shall notify consumer to curtail or shut off entirely the power supply, for other than emergency cases, on more than five (5) days.

. . . .

(f) The minimum monthly gross charge to be paid by consumer will be an amount equal to one dollar and twenty-five cents ($1.25) per kv-a of the maximum significant peak at any time created, subject to the limitations enumerated in Schedule "J" under paragraphs 1, 2 and 3 of Section b. of "Minimum Charges." The minimum monthly charge is not subject to term block discounts.

Problem C

An example of the standard method of calculation follows:

Determine the cost of 657,000 kwh at a maximum demand of 3,000 kva.

DETERMINATION OF QUANTITY BLOCKS.

First Block:
70 hours' use of the maximum demand:
70 × 3,000 = 210,000 kwh (A).
Second Block (difference):
657,000 — 210,000 = 447,000 kwh (B).

DETERMINATION OF COST.

210,000 kwh at $0.06 =	$ 12,600.00	
447,000 kwh at $0.0125 =	5,587.50	
Total gross cost		$ 18,187.50
Discount:		
On $1,800*	$ 375.00	
43 per cent on $16,387.50 (difference)	7,046.62	
Total discount		$ 7,421.62
Gross less term discount		$ 10,765.88
Less 2 per cent for prompt payment		215.31
Total net power cost		$ 10,550.57

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*Obtained by integrating the eleven block discounts up to and including $1,800.00.

Equation Form

The complicated wording of the contract can be stated much more simply in equation form, but the amount of calculation required to solve a problem is the same by either method.

Let D = maximum demand, kva†
Let E = total energy metered (month) kwh

Then:

Total gross cost = $(4.2\ D) + .0125\ (E - 70\ D)$
Term discount = 0.43 (gross — \$1,800.00) + \$375.00
Total net cost = 0.98 (gross less term discount)

The preceding formulae apply only for load factors exceeding 9.6 per cent, or in the portion of the chart to the right of line "B." Below 9.6 per cent load factor use the equation: Cost = .0335 × kwh + \$382. The bill calculated by this formula may be less than the minimum charge, in which case the latter applies.

Graphic Determination of Cost

The accompanying chart (for large consumers) was designed with two purposes in view: First, to facilitate the checking of power bills by means of a chart instead of by calculation; and, second, to put the conditions of the contract into such form as to allow a visualization of the terms, and of the effects of the several factors which affect the cost of the service. The latter phase will be reserved for a later article. The first phase will be demonstrated after the construction and use of the chart have been explained.

There are five variables represented on the chart: kwh consumed, monthly power cost, demand, rate per kwh, and load factor. Each variable is represented by a "family" of lines, and if any two of the five variables are known, the intersection of the lines representing the particular values of the variables determines at once the other three variables. Vertical lines are lines of constant energy consumption; horizontals are constant monthly costs; constant demand lines are parallel to each other and have a slope of about 20 degrees in the major portion of the chart. The constant unit rate lines are radii from the intersection "X" at the lower left-hand corner of the chart, and are marked, e. g., \$0.011 (per) kwh. The constant load factor‡ lines are also radial, but it is unfortunate that their center is so near and yet not co-incident with the center of the other radial lines. For this reason these lines are not drawn on the chart, but are indicated by a load factor scale. Any load factor line is determined by the value on the scale and the common point "D." A ruler or other straight-edge may be placed to represent any load factor line, but it is suggested that if the user of the chart makes frequent reference to this variable, that the lines be drawn with red ink.

Two other lines are significant. The dot and dash line "B" marks the division between the first and second quantity blocks, and represents 9.6 per cent load factor, since the first quantity block is 70 hours use of the demand, and one month = 730 hours. 70 ÷ 730 × 100 = 9.6 per cent. The significance of this line and the blank area to the left of it will appear in problems D and E. Line "C" is the 100 per cent load factor line, and marks the normal boundary of the chart, because in order to have an actual load factor of 100 per cent, the maximum demand must be carried continuously throughout the entire month. A peculiarity of this schedule, however, is that consumers who purchase power under the "off-peak" or "limited" service clauses may have an "apparent load-factor" greater than 100 per cent. This is because under the terms of these clauses, the billing demand is taken as a fraction of the metered demand. For example, suppose 730,000 kwh are used on a metered demand of 2,000 kva. The actual load factor $= \dfrac{730{,}000 \div 730}{2{,}000} \times 100 = 50$ per cent. But for off-peak service the billing demand is taken as 25 per cent of the metered demand, which in this case is 2,000 × .25 = 500 kva. The apparent load factor $= \dfrac{730{,}000 \div 730}{500} \times 100 = 200$ per cent. Similarly for "limited" service, the billing demand is taken as 70 per cent of the metered demand, and a similar result is possible. Such cases, however, are exceptions to the general rule, and it was not deemed advisable to extend the range of the chart beyond 100 per cent load factor. In such instances, the chart can be used by extending the demand line affected to the right until the necessary point is reached.

Example

For a working example in the use of the chart, suppose the following bill is rendered, and is to be checked:

(It will be noted that this is the same as problem C.)

9-24 21	1,893,500
8-24-21	1,236,500
	657,000 kwh consumed
(Demand = kva 3,000)	
210,000 kwh at \$.06 = ...	\$ 12,600.00
447,000 kwh at .0125 = ...	5,587.50
	\$ 18,187.50
Quantity discount	7,421.62
	\$ 10,765.88
Subject to 2 per cent discount as per amount deducted provided payment is made on or before April 4, 1921..................	208.32
	\$ 10,557.56

The given conditions are: 657,000 kwh and 3,000 kva demand. Starting at 657,000 kwh on the lower scale (energy consumed) follow vertically until the 3,000 kva demand line is intersected. This intersection determines the significant point from which all the unknown quantities may be determined. Following horizontally to the left, the power bill is found to be about \$10,490, which checks within one-half of one per cent with the bill as rendered. If the unit rate is desired, it is seen that the significant point falls exactly on the \$0.016 line; hence that is the cost per kw hour. Further, a straight edge placed so as to intersect the circle "D" and 30 per cent on the load factor scale, also intersects the significant point, hence the monthly load factor was 30 per cent.

Problem D

In cases of such low load factor that the energy consumed is less than 70 hours use of the demand, the significant point falls on line "B" and depends only upon the energy consumed.

---

†This may be determined by any of the several methods which depend upon the class of service. The controlling value is always indicated on the bill.

‡The term "load factor" is used in these articles in the sense as defined by the A. I. E. E., i. e., the ratio of average load to maximum load.

This is illustrated by: 218,000 kwh at 3,800 kva demand. It will be found that a vertical line from 218,000 kwh does not intersect the 3,800 kva demand line, hence the significant point is determined by the intersection of this vertical with line "B." Following to the left from this point, the cost is estimated as $7,700. (The calculated value is $7,697.51.)

Problem E

The location of an error when a bill does not check is demonstrated by the following:

9-24-21	6,176,000	
8-24-21	5,236,000	
	940,000 kwh consumed	
(Demand = kva 3,200)		
352,000 kwh at $.06 = ...	$ 21,120.00	
588,00 kwh at .0125 = ...	7,350.00	
	$ 28,470.00	
Quantity discount	11,843.10	
	$ 16,626.90	
Subject to 2 per cent discount as per amount deducted provided payment is made on or before April 4, 1921..	332.54	
		$ 16,294.36

By the chart it is determined that the cost is about $12,800, which indicates that the bill as rendered is about $3,500 high.

As the extensions check all right, the next step is to check the quantity blocks. By finding the intersection of the 3,200 kva demand line and line "B," read vertically downward to the energy scale, and it is found that the first quantity block should be about 224,000 kwh, instead of 352,000 as billed. As the second block represents the difference between the total consumption and the first block, it must have been calculated too small. Thus, since the quantity block which carries the higher unit rate was erroneously billed too large, and the block which carries the lower unit rate too small, it is apparent that the source of the error was in the determination of these blocks. The statement should, of course, be returned, with attention directed to this fact.

The value of the chart as a check on power bills has now been estabished, but this is only one of the uses to which it may be applied. Its application to the analysis of power costs as affected by the selection of the proper equipment, and the load characteristics of the equipment when in service, is equally, if not more important and valuable than for the purpose explained here. These considerations, however, will be treated in a later issue.

Galvanizing Sheets of Steel

Process by Which Galvanized Sheets Are Treated—Process of Coating Iron and Steel Sheets With Zinc—Essential Requirements of Galvanized Sheet Steel.

By C. A. DAVIS.

THE trade name "galvanizing" is given to the process of coating iron and steel with zinc. In this process, the sheets are first assembled as to gauge and widths in what are known as drafts or batches. A batch is loaded into a crate, which is made of some acid-resisting metal, and transferred to a wooden tank which contains the pickling solution and is known as the pickling tank. This pickling tank contains a solution of sulphuric acid and water of the proper strength. The action of the acid in this tank is aided by a plunger working perpendicular to the batch in the tank, which causes the pickling solution to wash evenly between the surface of the sheets.

From the time the sheets enter the pickle tank, a careful watch is kept on the same by the man in charge of the tank, called the pickler, whose duty it is to determine how long said batch shall remain in operation. This he determines by the appearance of the edges of the sheets in the batch on the up-stroke of the plunger, as the acid replacing plunger exposes the top edges about four inches.

After properly pickling, the batch is lifted from the pickle tank to one of the same construction containing water, and used solely as a rinse tank. From this tank it is again lifted to the third tank, which contains lime water. The purpose of this operation is merely to preserve the color of the sheets after pickling, so the same can be carefully sorted into water crates, where they are submerged in a shallow tank of clear running water, after which they are returned for galvanizing.

The value of coating iron or steel with zinc, thereby protecting the material against corrosion, is dependent to a large extent on the uses to which the customer desires to put the coated material. The process of coating is as follows:

After careful inspection of the sheets in the final water crate, they are transferred to a tank containing a weak solution of muriatic acid, which serves as a final wash for impurities. From this point, the sheets are fed one at a time into the galvanizing machine. This consists of a heavy steel housing, in which rest three pairs of 8-inch rolls, namely intake, bottom and exit rolls, submerged in the molten metal or metals with which the sheets are to be coated; the surface of the molten metal being covered with a substance which serves to prevent oxidation. A man at the pot tank feeds the sheets one at a time into rubber rolls, which are mounted on top of the tank. These rubber rolls carry the sheets into the intake rolls which, with the assistance of guides, cause the sheet to pass into the bottom and likewise into the exit or finishing rolls. From the exit rolls the sheet is carried flatwise on a chain conveyor into a roller leveler which straightens or flattens the sheet. From the leveler the sheet is conveyed by chain into a cooling wheel, where it is allowed to cool slowly.

Youngstown Sheet and Tube Bulletin.

On the Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesman Pilgrim-step Rolling Mill.

Dy. DR. ING. KARL GRUBER in Rheydt.

PART IV.

IN this process a hollow bloom on a mandrel is worked between rolls so that a short part of the hollow bloom is rolled into a tube at each revolution of the rolls. We will call the end of the hollow bloom that points to the rolls, the front part, the one pointing in the opposite direction, the back part. The patent specification No. 58762, which describes the invention in detail gives various ways in which the operation may be carried out. First of all, a distinction, as to the direction in which the rolls move, is made. Experience has shown that it is desirable for the rolls to move from the front end towards the back end of the hollow bloom, i. e., the opposite of what is usual in ordinary rolling where the work is drawn into the rolls.

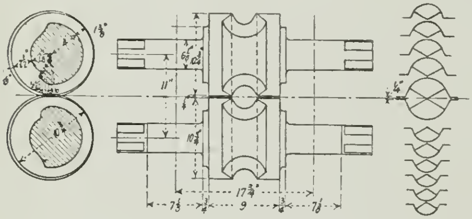


Fig. 31—Pilgrim step finishing rolls showing pass sections of the rolling cone.

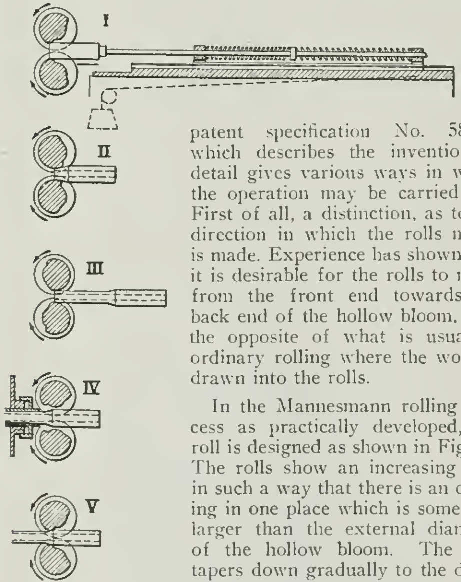


Fig. 32 — Successive steps in the progress of the work on a Pilgrim rolling mill.

In the Mannesmann rolling process as practically developed, the roll is designed as shown in Fig. 31. The rolls show an increasing pass in such a way that there is an opening in one place which is somewhat larger than the external diameter of the hollow bloom. The pass tapers down gradually to the diameter of the finished tube. This point will be dealt with in detail when the different operations in the various positions of the rolls are discussed. The rolls are further provided with slightly opened sides in accordance with patent specification No. 88638 in the way usual with rolls for round bar, and this point is of importance in tube rolling, as it prevents the tube jamming on the mandrel.

For insertion into the roll of the material which is pushed back at every operation, a feeding device is provided enabling the mandrel to move to and fro in a flexible manner, while at the same time insuring a step by step forward movement of the mandrel together with the hollow bloom which rests on the latter. The operations (see Fig. 32) in the rolls are as follows:

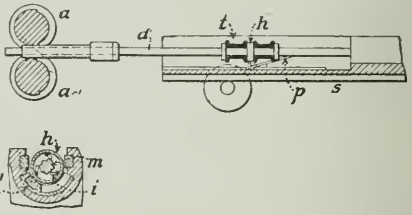


Fig. 33—Arrangement for automatically rotating the hollow ingot through 90 degrees.

In position 1 of the rolls the pass leaves a space between them into which the hollow bloom may be inserted. To limit the feed motion a stop is provided at the rear of the roll center which is so arranged that the rolls are given as much material as they are able to roll out in one revolution. In the smaller rolling mills this feed motion amounts to about 22 mm of the length of the hollow bloom. As the rolls continue to rotate in the sense of the arrow, the hollow bloom is gripped by the rolls, as shown in position 2, because the pass begins to become narrower at this point. It is the work of the so-called roll taper by which the pass is gradually narrowed farther down, as the rotation continues, up to a point when the correct diameter of tube is reached, as shown in posi-

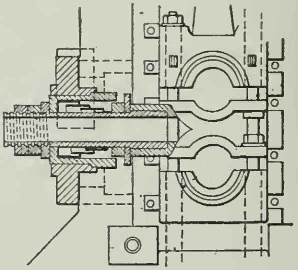


Fig. 34—Bearings for the rolls and exit guide on a small Pilgrim rolling mill.

tion 3. The rolling process proper, therefore, takes place during rotation of the rolls from position 2 to position 3. During the two operations the bloom is pushed back together with the mandrel. The forced backward movement of both mandrel and bloom, as caused by the roll, acts against the pressure of a spring or an air cushion of the feeding device. This pressure, more especially in the beginning, is smaller than the force by which the rod is pushing back the work. But as soon as the work is released again by the roll, the hollow bloom is thrown forward again together with the mandrel rod, until stopped by the stop provided. In order to insure the tube being released by the rolls, the pass of the latter at this point, as per position 4, is increased and continues increasing up to a size of pass which will admit even the external diameter of the hollow bloom.

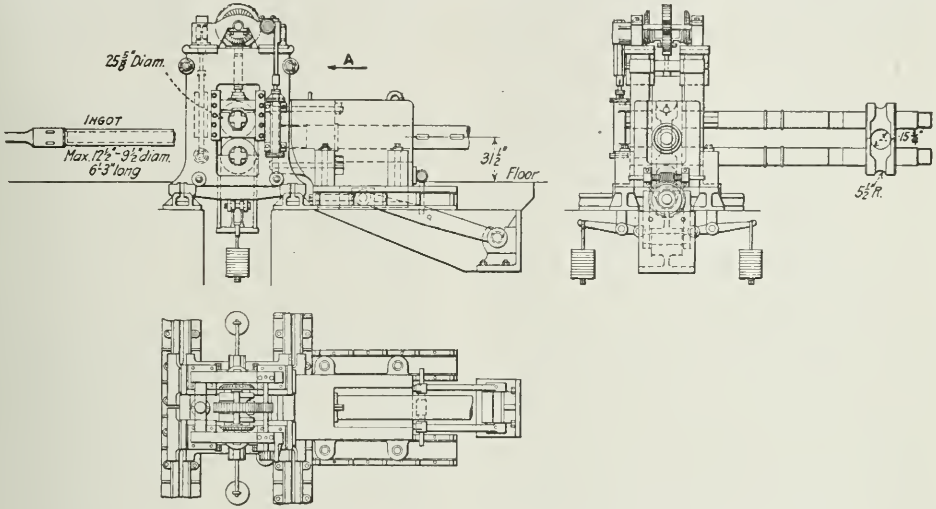


Fig. 37—Elevations and plan of a 25-inch Pilgrim step rolling mill.

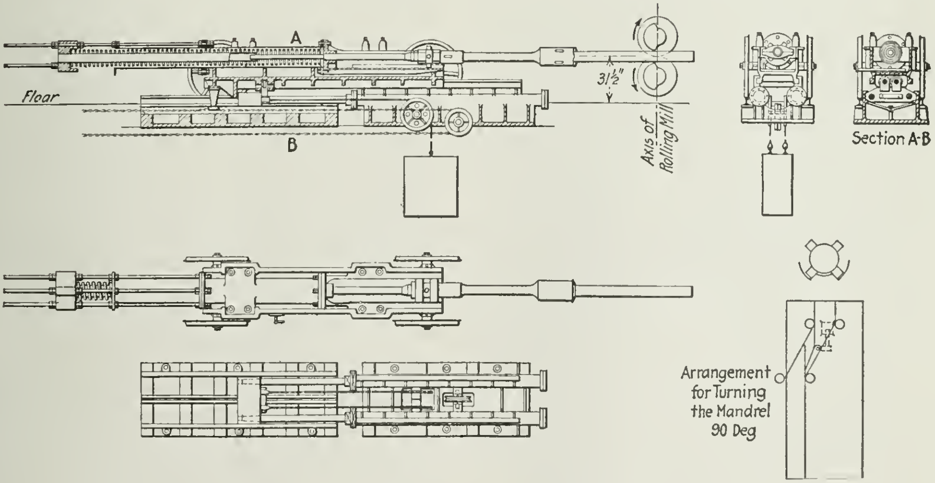


Fig. 38—Plan of the carriage on which the ram works back and forth in feeding the hollow ingot through the rolls.

Position 5 is the position immediately preceding position 1, and from this point the cycle is repeated.

Mention has to be made of the important fact that the hollow bloom is rotated through 90 degrees at each revolution of the rolls, thus shifting the worked surface of the hollow bloom after each revolution of the rolls by this angle. This rotary movement of the mandrel rod is also effected by means of the feeding device in this way, that, by the reciprocating movement of the mandrel, a helical movement is imparted to an extension of the mandrel rod.

Patent specification No. 155228 deals with a feeding device in which the shifting of the work is independent of its feed, as shown in Fig. 33. The top drawing shows how the device is arranged. A ratchet wheel m is mounted on the mandrel rod d. The sleeve h enclosing the ratchet wheel, and the pawls i (see cross section) are moving in unison with the slide t, which is connected to the mandrel d, the sleeve engaging in the helical groove p of the slide by a stud h'. This helical groove p has rectilinear shape at the end farthest from the rolling mill, causing the angular shifting of the work towards the end of the forward stroke, independently of the stroke of the work itself. The device can, therefore, be used to advantage in rolling tubes on the Perrins process (Auspilgern) in such cases when the tubes on account of their cross section can only be rotated through a certain angle in order to insure proper insertion into the rolls.

The slide is connected to springs in the usual fashion, which are compressed when the mandrel rod is pushed to the right, and feed forward the work as soon as it is released by the rolls.

When the mandrel d slides to the right as the rolling proceeds, the pawls of the rotating sleeve glide over the teeth of the ratchet wheels. On the backward movement of the mandrel, however, the pawls engage with the teeth of the ratchet wheel m, thus coupling the rotating sleeve with mandrel rod, mandrel and work, and in this way effecting the angular shifting.

The drive of the rolls and the construction of the housings is essentially the same as in standard rolling mills. The rolls are set by hydraulic or electric power and the large rolls are hydraulically balanced. The drive of the rolls is also effected in exactly the same way as in standard rolling mills, viz., by means of a spindle box. As there are jerks at each revolution of the rolls when the latter grip the material, and owing to shocks at the stop, it is advisable to make the housing of cast steel. Besides this heavy foundations for the housing have to be provided.

In the small rolling mills the stop can be a flexible one (Fig. 34). In the larger rolling mills, i. e., those for tubes of up to 11 inches, it is of considerable bulk capable of taking the shock. Figs. 35 and 36 show the arrangement in principle of a rolling mill of this description, which is of an early design.

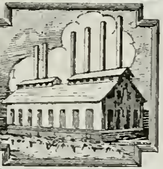
The feeding device, as has been mentioned before, serves the purpose of effecting the feed step by step, and of imparting the reciprocating motion to the mandrel rod and its extension, further of rotating the hollow bloom through 90 degrees for each revolution of the rolls. As shown by Fig. 36 the feed motion used to be effected by means of a weight attached to the slide. There was another chain attached to the slide which could be slackened by a special device whenever the feed of the slide was to be actuated, viz., after each revolution there was a jerky slackening, so that the weight was able to act. These constructions have been superseded by hydraulic appliances.

STEPPING ROLLER WELDING MACHINE.

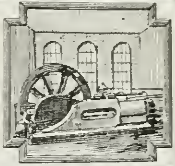
This new electric welding machine works on the principle of resistance welding. The older types of seam welding machines used to work with uniformly turning welding rolls in such a manner that, an alternating current of low pressure (1-4 volts) and high amperage was transformed in the machine in passing from one roller to the other through the path to be welded. The material to be welded was inserted between the two rollers. The resistance which is offered to the passage of the current at the surface of the contact of the two pieces of material to be welded together, converts the electric current into heat. The material is brought up to welding temperature and is joined together by the pressure of the rollers. By the uniform rotation of the roller the seam passing between the two rollers is welded together in one uninterrupted operation. The working speed is comparatively high amounting to 1¼ to 1¾ inches per second with sheet metal of about half a millimetre thickness. This apparently rapid process has nevertheless not been introduced to any great extent. It was too sensitive even against slight impurities of the welding surfaces and small obstacles in the rotation of the rollers, and for this reason it has in fact never been possible to assure with this process a permanently satisfactory operation. The stepping rollers process placed on the market by the Gesellschaft fuer elektrotechnische Industrie in Berlin has remedied the faults adhering to the former method. With this new process the welding rollers do not turn uniformly, but after a partial turning movement they are arrested for a moment in order to proceed with another partial turning movement. Such partial turning movements (steps) are made by the roller to the amount of 10—800 per minute, varying according to the thickness of the material to be welded. At every partial rotation a distance of from 1/16 to ½-inch is covered by the roller, this distance varying with the thickness of the material. The welding current is coupled to the movement of the roller in such a manner that at the moment when the roller comes to rest, after having completed one step, the current is switched-on. The part of the material below the roller at that time is heated up to welding temperature and is welded by the pressure resting upon it. Immediately afterwards, the current is interrupted for a short period, the roller will keep up its pressure upon the welded part, until the latter has cooled down under this pressure and under exclusion of air to such an extent that sufficient strength is obtained to prevent the material being torn apart by any tension in the material. This new process has shown excellent results; even sheet metal with very unclean surfaces covered with scale has been welded according to this process in a faultless and clean manner. The reliability of the operation of this new machine is so great that it has become possible to design automatic seam welding machines on this principle up to any output. The wear of the electrodes which was very considerable with the older process is very small with the stepping roller; even if the sheets are covered with scales the electrodes remain perfectly clean.

SHEET METAL CONTRACTORS.

At the closing session of the seventeenth annual convention of the National Association of Sheet Metal Contractors held at the Fort Pitt Hotel, Pittsburgh, June 17, Arthur P. Lamneck, of the W. E. Lamneck Co., Columbus, O., was elected president. Indianapolis was selected as the convention city for 1922 and the trustees of the organization were authorized to invest $5000 in government securities. Other officers elected are Frank Higgins, St. Louis, John A. Pierpont, Washington, George P. Werner, Galveston, Texas, and D. M. Haynes, Chicago, vice presidents; Edwin L. Seabrook, 261 South Fourth street, Philadelphia, was re-elected secretary and Julius Gerock, St. Louis, treasurer. W. A. Fingle, Baltimore, Frank Hiller, Cleveland, and R. E. Pauley, Mason City, Ia., were elected trustees.



STEAM POWER DEPARTMENT



Modern Steel Works Power Plant

In These Days When Economical Production Is Such a Main Issue In Manufacture of Steel, Power Plants Offer Such Possibilities of Saving That They Must Be Carefully Considered.

By W. N. FLANNIGAN,[*]
Steam Engineer, Ohio Works, Carnegie Steel Company.

PART II.

IT has often been suggested that the future utilization of coal for power will consist entirely of the manufacturing of coke in by-product ovens, the gas being used in engines or as domestic fuel and the coke being burned under boilers, full value of all the by-products being realized. This scheme is entirely logical, but at the present price of coal and demand for by-products it is not as yet attractive to power plant owners in this country, whether steelworks or public service corporations, on account of the tremendous outlay involved. Coke ovens are used only where there is a direct demand for coke or gas.

Theoretically the next most nearly ideal way is to burn the coal in powdered form. With this system, cheaper buildings, excellent control, perfect mixing, and elimination of ash and excess air losses are obtainable, as well as extremely high efficiencies by the use of air heaters which are considerably less expensive than economizers. However, due to operating difficulties encountered, these advantages are not being fully attained in boiler practice. When coal is burned with the theoretical amount of air, a very high flame temperature is produced, which is hard on brickwork and which liquefies the ash produced. To eliminate brickwork trouble, and also the liquid ash, which in earlier installations coated the tubes, large quantities of excess air were used which did away with some of the operating trouble, but also with one of the advantages, namely, increased efficiency due to the elimination of excess air loss, which amounts to from 5 to 10 per cent in an average stoker installation. No air heaters have been installed, which means another advantage lost.

Combustion chambers have been made large which, while it makes combustion complete and helps to deposit ash before the gases strike the tubes, increases the radiation loss and the space required. Such large combustion chambers have not been found necessary in some heating furnaces. For instance, in heating furnaces 10 pounds of coal per hour are being completely burned per cu. ft. of combustion chamber. In other words in heating furnaces an equivalent of 1/3 of a cu. ft. of combustion chamber per boiler hp developed is being used while 1 to 2 cu. ft. are used in boiler installations, both with stokers and with pulverized coal. Part of this rapid rate of combustion is accounted for by the fact that the flame is surrounded completely by either hot walls or hot steel, while in a boiler part of the combustion chamber is usually exposed to cold tubes. However, the greater part of the credit is due to good mixing, uniform feeding, and preheated air. Good mixing is dependent upon two factors; sufficient velocity to cause turbulent flow, and fine enough subdivision of the coal so that intimate contact with the air is assured.

The ideal and readily attainable installation will consist of a combustion chamber not any larger than for stoker practice, the burners being pointed downward allowing the flame and gases to reverse through 180 degrees before striking the tubes. The burner should be so designed that velocities above the critical will be obtained, which will give good mixing and perfect combustion with practically no excess air. The boiler should be equipped with integral air heater at the stack using the heat in the waste gases. The high flame temperature will slag a large part of the ash, which will be dropped into the bottom of the combustion chamber from which it can be run out in liquid form. The balance of the ash will pass through the boiler and out of the stack or can be removed from soot pockets in the setting in powdered form. The combustion chamber walls can be protected by passing the air from the air heater through them.

The present disadvantages of pulverized coal are:

1. The initial expense of the pulverizing plant required.
2. The labor necessary to safely operate the pulverized coal installation is as great as for stokers unless the installation is very large.
3. Danger of explosion or spontaneous combustion.
4. Pulverized coal bins are required at the furnaces or boilers.
5. Feeders and fans require power same as stokers.
6. Present feeders do not proportion correctly, i. e., for a given speed the feed varies due to different density, or aeration, and to varying moisture and fineness of coal.

Paper delivered before American Iron and Steel Institute, May 28, 1921.

7. High cost of pulverizing.
8. Coke breeze cannot be pulverized economically on account of its abrasive nature.

None of the above difficulties are insurmountable, in fact most of them will be eliminated by apparatus just now emerging from the experimental stage.

Disadvantages of initial outlay and labor are more than compensated for by the higher efficiencies obtainable if pulverized coal is properly burned. The cost of pulverizing is being decreased due to improvements in pulverizers.

Much of the danger and all bins at the furnaces can be eliminated by circulating the coal in a solid stream through standard steel pipe by means of a pump and taking off what is needed by means of feeders, as the pipe passes the boiler or furnace. This eliminates expensive and space occupying bins and all danger of dust explosions or spontaneous combustion in the boiler house. This system has just been devised and developed and has, therefore, not been used in power plants, although it is readily adaptable. Since it furnishes a means of eliminating bins and danger it is only a matter of time until it will be found in use in power plants.

Danger in the pulverizing plant can be eliminated by proper dryer operation, by elimination of air flotation in the shortest possible space, and by a spare pulverizer in connection with the above mentioned feeding system which will eliminate the necessity of a large pulverized coal storage.

The latest feeders and burners developed agitate the coal just above the feeder proper, so that the coal always reaches the feeder or measuring device in the same stage of aeration, or fluffing, and with the effect of packing or caking eliminated. A feeder of the above type including the fan takes less power than a stoker and its forced draft fan, and perfect regulation and combustion can be secured by proper burners, which should be more than a couple of pipe fittings, as is usually found. Proper attention to mixing and to gas velocities has amply repaid the efforts in burning gas, and the same holds true of coal burners.

In addition to the high efficiency possible there is also a flexibility and ability to meet peaks that can only be obtained otherwise with a gas or liquid fuel. The standhy losses are very small as banked fires are not necessary and the boiler can be entirely closed up when not required, and kept hot for long periods. Low-grade fuels, which would cause trouble on stokers or with hand firing, can be burned with little difficulty in the pulverized form, as high sulphur, sticky or excessive amounts of ash can be disposed of in liquid form. The only limit is when coal contains so little volatile matter and so much ash or foreign matter as to render ignition difficult or impossible.

In the case of boilers fired with blast furnace gas pulverized coal furnishes an excellent fuel for standby service when the gas is off, since it can be fired in the same boilers as gas, and in the same manner; no banked fires are needed, no grates or stokers need be protected; and no time or labor is lost in starting up the coal if the gas supply is shut off suddenly.

The fact that stoker firing has made so much progress in power plants and pulverized coal so little is due, in addition to being unadapted to coke breeze, to slow development of pulverized coal apparatus, and not to a lack of realization of the advantages of pulverized coal. Apparatus that is adapted for boiler house use and requiring not too expensive an initial outlay is just being developed so that pulverized coal is more a feature of future than of present boiler plants.

Small pulverizers directly supplying individual units were tried out and discarded soon after pulverized coal began to be used. These machines take crushed coal directly, without drying, pulverize it, and blow it into the furnace mixed with at least part of the air for combustion. Poor regulation both of air supply and fineness, inability to pulverize finely, excessive repairs to high speed machinery, in addition to poor design and improper installation caused the abandonment of this scheme by many plants, including cement mills. Lately, however, this system has again found champions and is being pushed by at least two concerns, while some experimentation is being done by individual plants, including one steel works.

The advantages of such a system are very apparent, namely, elimination of handling and storage of pulverized coal, applicability to any plant regardless of size, system can be readily expanded, separate buildings not required, elimination of dryers, and elimination of most of the danger. However, up to the present time the advantages have been overbalanced by the disadvantages stated before, namely, poor regulation of air, lack of fineness, excessive repairs and the necessity of coal bunkers with coal handling machinery at each unit or group of units. There is also the possibility of burning back through the pipe to the pulverizer on shutting down.

Boiler Control.

Until the last few years conditions were tolerated in the boiler room which were eliminated in the engine room a century ago. The first steam engine had no automatic valve gear for feeding steam to the cylinders, but had a boy to operate the valves at each stroke. The engine had no governor, but on account of close attendance, slow speed and the fact that it did not have to operate in parallel with other engines, the governor was not as necessary as it is today. Imagine the engineer of today throwing the valves of a high speed engine by hand and also trying to keep the engine at a constant speed and in parallel with other units under a varying load. The above is hard to imagine now, but it is closely analogous to the boiler operation in many plants today and was the condition in all boiler plants a few years ago. The fireman and watertender had to feed coal by hand supposedly in proportion to a load of which they had no indication, they had to try and keep the boiler doing about the same as other boilers, but they had only a vague idea of what the other boilers were doing. They had to try and keep the steam pressure constant, but until the pressure had either dropped below or risen above normal and was indicated by a gauge, if they happened to look at it, they did not know whether more or less fire was needed. Fortunately, the boiler had no flywheel to burst and the safety valves usually took care of excess pressure, while the engine governor and valve gear took care of varying steam pressure, and economy suffered.

(To be continued)

Powdered Coal as Fuel for Boilers

A Complete Review of the Application of Powdered Coal As a Fuel In The German Steel Industry.

By DIPL. ING. F. SCHULTE.*

The present article is believed to be of interest to the American fuel engineer, because it illustrates German practice and ideas in regard to the application of powdered coal as fuel under boilers. While in the United States powdered coal has, to a large extent, been used as fuel in industrial plants and mainly in different kinds of metallurgical furnaces, the development of coal dust installations in Germany was slow and its use was more or less restricted to a certain type of boilers. The reasons for these conditions are explained in this article.

THE first plants with powdered coal installations at the Industry Exposition at Berlin, 1906, caused considerable comment. That the expectations, the fulfillment of which had been hoped for, were not realized at the beginning, was partly due to the then undeveloped means of grinding and crushing, partly to the difficulty of obtaining highly refractory material and, finally, to the development of mechanical stokers, which forced powdered coal installations to the rear. It is mainly the cement industry, which, disregarding the many failures, has developed powdered coal furnaces to such an extent that, today, they can be used with advantage in other industries. It must, however, be kept in mind, that the cement industry offered very favorable conditions. In the revolving kiln very high temperatures are required for sintering the cement, which high temperatures can easily be obtained with powdered coal. The removal of ashes and slag can be done without difficulty and the heat requirements are uniform. The combustion chamber is slanted downward, there are no large cooling surfaces and the refractory material is exposed to less strains and harder wear than in other types of furnace. But, nevertheless, it took a large amount of work and money, to overcome the difficulties, which originated in the incomplete combustion of too coarse fuel.

In a powdered coal furnace, the fuel, as the name implies, is introduced into the combustion chamber in the form of dust. Powdering is done in three operations, namely: preliminary crushing, drying and grinding.

Coal pieces larger than one inch must be crushed, which is done in crushers, built similar to those used for crushing hard material. Such a crusher can handle between 8 and 25 tons per hour, requiring approximately from .5 to 1.5 kwh per ton.

Before the crushed coal enters the dryer it runs through a magnetic separator, in order to free it from iron particles. The dryers are mostly direct fired drums, which, for the purpose of facilitating the movement of the coal, are slanted and built in such a way that they can be revolved. With the simplest design the furnace is arranged under the front half of the drum. The gases of combustion first play around the outside of the dryer, then enter the inside and come in direct contact with the coal to be dried. After being separated from the suspended coal dust, they are carried away by the stack. A design which differs somewhat from the one just described, has been developed by the "Gruson" works at Magdeburg and is shown in Fig. 1. The coal to be dried travels through an annular drum, whereas the gases of combustion first heat the outside of the drum and then pass out through the inner drum.

Dryers are mostly hand-fired; large installations, however, may be fired with powdered coal. The coal in those drums, which permit a direct contact of the coal with the gases of combustion, should never have a higher temperature than 250 degrees F., otherwise the coal will be gasified and deprived of its most valuable constituents. The regulation of the temperature is done by admitting outside air, and this is the reason that an installation of this type works with a large excess of air. The efficiency of the fuel is, therefore, very low and will hardly be more than 25 or 30 per cent.

On account of these conditions and due to the necessity of drying the coal dust to .5 or 1 per cent moisture, the plant must be under careful surveillance, otherwise losses will occur by driving off part of the volatile matter. According to the efficiency given above, a coal consumption of 3 per cent is required for every 10 per cent of moisture contained in a coal of 12,600 Btu. Brown coal can only be dried to the moisture contents of briquets (16 to 18 per cent), on account of the danger of explosion. The power necessary to operate a drying installation amounts to about 1 kwh for every ton of dried coal.

The grinders are either of the slow revolving or of the quick running type. The first kind is especially highly developed in Germany and includes ball mills and "tube" mills. The short ball mills with their large diameter are not very well adapted for coal grinding; better are the tube mills, which have their name from their long tubular shape. In the general design they mostly consist of a rougher, in which the coal is ground by means of steel balls, and of a finisher, which contains pieces of flint. (Fig. 2.) The coal enters the first compartment with nut-size and is ground there to grit, and in the second compartment to the required powder. Powdering is done by the action of the falling stones and balls. The fineness of the dust is determined by passing it through a sieve of known mesh. As a general rule it can be said that the coal is fine enough, when 90 to 95 per cent go through a sieve with 180 mesh.

From "Glueckauf," April 30, 1921.

The slow working mills are high in first cost and need considerable power (30 to 60 kwh per ton of dust according to the fineness of grinding). But they are, on the other hand, very reliable; they do not require large repairing and they furnish a dust of a high fineness. The manufacturers of this type expect to be able to reduce the power requirements considerably. If the material, entering the grinder, is of grit or still finer size, the front part of the tube mills with the steel balls can be dispensed with, which will reduce first cost and operating cost.

Of the quick running mills, which are chiefly developed in America, a large number of different types are on the market. The widest distribution have the Aero-mills with pestles which are attached loosely to a cross and which move in the stationary drum; the Raymond mill with short rollers suspended like pendulums; the three-roller mill with three rollers revolving in a movable drum; and the Roulette or Fuller mill with revolving balls. In the last type and in the two first-named types the coal dust is ground between the grinding bodies and the shell of the drum, against which the grinders are pressed by the action of the centrifugal force. In the three-roller mill the rolls are pressed down by means of springs.

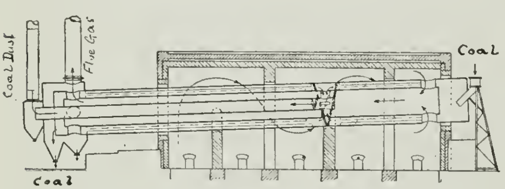


Fig. 1.

The quick runners are much less expensive than the slow working types; they, furthermore, require less space and power. According to American data, 10 to 30 kwh are necessary to grind one ton of coal dust. Reliable test data are not yet at hand in Germany. It seems, however, that the Aero mill does not come up to requirements in regard to the fineness of the coal dust. As disadvantages of the quick operating mills must be mentioned much larger operating and maintenance cost and the impossibility of grinding the coal fine enough.

Coke and anthracite are the kinds of coal which are hardest to grind. The easiest to grind is bituminous coal, somewhat less easy is gas coal. It is a known fact that bituminous coal disintegrates readily into dust, whereas gas coal breaks, when ground, first into splinters. It is, therefore, not right to say, that a coal can be ground the easier, the higher its content of volatile matter. The easiest grinding can be done with a coal with about 20 or 30 per cent of gas-content. Dry brown coal can also be ground without difficulties, as can the semi-coke or carbo-coal, obtained at low temperature coking processes. It has been proven by tests that this carbo-coal can be easier ground than the coal out of which it is made. The selection of the type of mill to be used should be decided upon from case to case, under consideration of the combustion conditions mentioned below.

Tube mills are very expensive and their installation can only be considered for very large plants, where there is the only possibility of their efficient operation.

A coal dying and grinding plant, as designed by the Polysius Company, is shown in Fig. 3 The area covered by this installation is small, because the different apparatus has been located in different stories.

The separating of the coal powder is either done with sieves or with the aid of air. Sieve-operating is generally applied for the slow going tube mills, whereas, for the quick running types air-separating is used. Sieve-separating is more satisfactory, but it is subjected to heavy wear and tear and it requires very dry coal, because otherwise the sieves will be clogged up in a short time. Air-separating, on the other hand, is simple and can take care of wet coal.

The transportation of the coal dust from the mill to the furnace can be done in three ways, i. e., either by a screw conveyor, or by compressed air or by blowers. Transportation by means of screw conveyors is good and cheap, but it is limited to horizontal distances of not more than 200 feet. All joints the conveyor must be made air-tight, in order to prevent the entrance of moisture from the outside air whenever the mill is not working. For the transportation by means of dry air, a pressure of about 30 pounds is sufficient; it can be applied for distances of between 1,600 and 1,700 feet. Transportation by means of blowers, finally, is done with approximately atmospheric pressure. The two last named means of transporting are independent of a change in the direction of the flow, whereas the first named type is only adapted for short, straight distances. The air required is used for combustion and, in this case, it amounts to about 25 to 40 per cent of the total quantity of air required. Transportation by means of air needs about ten times as much power as transportation by means of a screw conveyor.

When air is used as the transporting medium, the coal dust is collected in a bin and conveyed from there to the burner by special appliances. Care must be taken that, with this kind of apparatus, a good regulation within wide limits of the fuel as well as of the air is possible. Feeding of the burner is mostly done by means of a small screw conveyor. (See Fig. 4.)

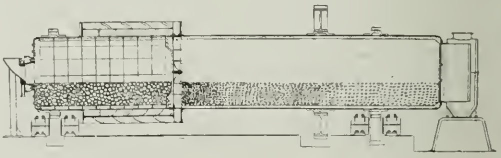


Fig. 2.

The coal dust must be fed into the burner uniformly and must be prevented from sticking in the storage bin. To prevent this trouble, the bins are sometimes supplied with agitators. If the powdered coal is burned immediately or shortly after grinding, that means in a warm state, transporting to the burners can be done without any difficulties, because warm coal dust flows like water, whereas cold coal dust often forms a solid mass, which can be cut with a knife.

The burner should be as simple as possible, because complicated types have not given satisfactory results. The burner not only serves for feeding the fuel into the combustion chamber, but also for mixing the powdered coal with the air necessary for combustion. The latter may be introduced either at the circumference of the burner or at its center. In both cases the mixing of the coal dust and the air must be complete before they enter the furnace. The combustion of coal dust requires only a very short time, in fact, it is just like an explosion. It can, however, be assumed, that everything which happens during the regular combustion of coal (preheating of the fuel, gasification and combustion) will also be found here, but that it will take place in a very short time.

Separate drying can be eliminated with ordinary coal, because it must be dried before grinding to .5 to 1 per cent moisture.

Of much importance is the determination of the conditions favorable or unfavorable for the combustion of powdered coal. A great advantage in every furnace is a high gas content. The combustion of the gaseous constituents of a fuel precedes that of the solid particles, and they generate, when burning, the necessary temperature and assist in obtaining a complete mixture of the coal dust and the air required for combustion. Another advantage is the possibility of obtaining a high temperature. In this respect, coal dust firing is superior to every other kind of firing. The temperature of combustion depends upon the heating value of a fuel. When comparing with gas and oil firing, it is well to use as a unit for the powdered coal the heating value of one cubic foot of the fuel-air mixture. The heating value of 1 cubic foot of the fuel, mixed with the theoretically required amount of air, is for

Blast furnace gas..	66 Btu.	Water gas	82 Btu.
Producer gas	73 Btu.	Illuminating gas ...	84 Btu.
Fuel oil	81 Btu.	Powdered coal	104 Btu.

It is assumed that the coal dust contains 10 per cent of ashes. Below can be found the theoretical flame temperatures for a fuel with from 12,600 to 14,800 Btu per pound, and for different amounts of air excess.

Air Excess Per Cent	Theoretical Flame Temperature Degrees F.
0	4080
25	3450
50	3000
100	2460
200	1650

In actual practice such high temperatures will not be met with, on account of a continuous heat loss through the furnace walls or heating surfaces. But actual temperatures of from 3,270 to 3,450 degrees F. have been observed with powdered coal. There is, of course, no brickwork which will withstand such high heats for any length of time, because a temperature of about 2,850 degrees F. must be considered as the limit for continuous operation. From this it follows, that the temperature must be lowered artificially by admission of a larger quantity of air, or that the furnace walls must be cooled by outside air to such an extent that a destruction is impossible. A direct contact between the heating surface and the flame has to be avoided, not only on account of an eventual destruction of the boiler plates or tubes, but also on account of the maintenance of the temperatures required for the combustion of carbon.

As was said before, it can be assumed, that in a coal dust flame first the gaseous constituents and then the solid particles will be consumed. The gaseous constituents can be burned in the open and the temperature required for burning can be obtained by the flame itself, but the heat and temperature necessary for preheating and gasification of the fuel must be at hand under all circumstances. The combustion of the solid particles requires a higher temperature, which can not be obtained by the flame proper. From this it follows, that the flame must be surrounded carefully with walls built of refractory material, otherwise there would be danger of unburned particles of coke entering the boiler. A combustion of these particles is not possible any more, because on account of the small amount of excess air there will be no excess oxygen left for the combustion of these particles. For this reason, powdered coal must be burned while in suspension.

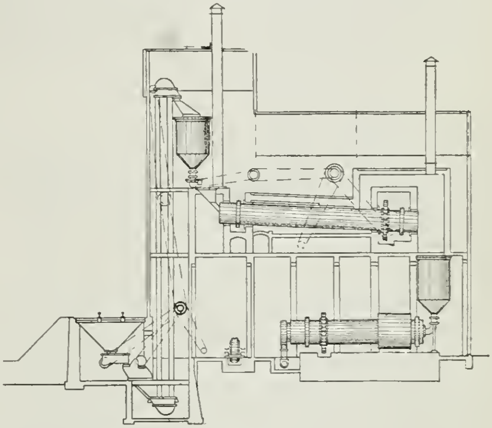


Fig. 3.

The combustion is supported by fine grinding of the fuel. The smaller the particle, the quicker it will reach the temperature required for combustion and the larger will be the surface offered to the attacking air, thus stimulating combustion. Another aid is a complete mixture of fuel and air, also facilitated by fine grinding, but made somewhat difficult on account of the different specific weight of coal and air, as well as on account of the large amount of air required for combustion. While low grade gases, for instance, blast furnace gas, require theoretically 1 cubic foot of air for 1 cubic foot of gas, richer gases, for instance, illuminating gas, 5 cubic feet of air per cubic foot of gas, 7,000 times the quantity of air is necessary for the combustion of powdered coal.

Experience obtained from burning gas has shown that it is difficult to mix thoroughly the richer gases with the necessary quantities of air. For this reason it is hard to burn coke oven gas satisfactorily without the use of burners which guarantee a complete mixture of gas and air. This is also the cause, that gas engines can be operated easier with lean gases than with rich ones. The mixing of the fuel and air when using powdered coal is, therefore, much more difficult than with the ordinary gaseous fuels. The best mixture would be reached when every dust particle would be surrounded by an air-globule, which would represent the theoretically required quantity of air. But such a mixture will never be found in actual practice. Such an air-globule will very likely contain several coal dust particles, whereas its neighbor may not have any at all. A steady exchange between dust and air must therefore prevail, which can be sustained by means of artificial air currents, even after the mixture has entered the combustion chamber.

Such currents may be obtained in different ways, one among which is the forcing of the coal dust air mixture into the combustion chamber with a certain velocity. In order to prevent explosions, the velocity of the mixture leaving the burner must be larger than the explosion velocity. On the other hand, it must be kept in mind, that the entering velocity must not be too big or the flame will become too long, which would be of disadvantage for steam boilers, the length of which is small anyhow. With a blast pressure of from 2.4 to 2.8 inches wc velocities at the burner mouth, as high as from 100 to 115 feet per second will be obtained. There are also coal dust installations for boilers which work without blast pressure. In this case they are built in such a way that the coal dust is mixed with the air in the combustion chamber, thus avoiding any danger of explosion. A natural mixture can be obtained, as was said above, by the gasification of the fuel, furthermore by a sudden high heating of the air, which, at 3,200 degrees F., occupies seven times the volume than at ordinary temperature. The mixture is also assisted by a central entering of the secondary air, which penetrates, on account of the sudden expansion, the veil of coal dust which surrounds it. The same effect may be obtained by the use of several burners, pointed against each other.

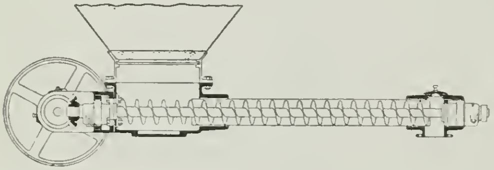


Fig. 4.

A good mixture will give a short flame, because the combustion is completed in a short time. Important for good combustion is also the shape of the combustion chamber, and it seems that this point has the same or at least a similar weight for powdered coal firing as it has for chain grates, although the work done by the two kinds of firing is not exactly the same. According to experience gained in America it appears to be evident that it is not so much the flame length which counts, but the flame surface. The flame should not have an elongated, but rather a spherical shape, so that the very hot core guarantees a certain and sure burning of the coal dust, and that the radiation to the surrounding furnace space is as small as possible.

The combustion is, as is the case with every other kind of fuel, retarded by the moisture contents, which with bituminous coal, of course, may be neglected on account of the preliminary drying. Another disadvantage is due to the high percentage of ashes. The latter, in turn, is followed by a lower heat value of the fuel and, therefore, a lower temperature of combustion. The ash and slag particles, remaining after burning the combustible parts, cause very disagreeable troubles. They sinter together and adhere to the heating surfaces; they settle as dust on every convenient place; they are carried through the stack and molest the neighborhood and form in the combustion chamber on account of the prevailing high heat the very much despised and feared liquid slag. The latter is very hard to remove and destroys the furnace walls. In the liquid state, the slag will naturally enter easily into the pores of the refractory material and into the joints of the wall, thus increasing chemical action. Another disadvantage is the high air excess, because it lowers the temperature of combustion, counterbalancing one of the main advantages of powdered coal firing. A large air excess, furthermore, increases the stack losses and decreases the efficiency. It must be said, however, that in the latter case the fuel-air mixture will be better, the possibility of complete combustion will be increased and the furnace walls will be better protected.

The preceding statements prove that there are important differences between all known modes of firing and powdered coal firing. It differs from gas firing, with which otherwise it has many points in common, that it requires a specially designed and preheated chamber of combustion, whereas gas burns right after lighting. On an ordinary hand-fired grate or with a chain grate, the volatile matter is burned above the grate and the solid matter within wide intervals on the grate. This is different with powdered coal firing, where there is really only a combustion above the grate, that is, the coal dust must be consumed as long as it is suspended.

To those points explained in the preceding paragraphs, grinding and combustion of every kind of coal must be adapted. A coal rich on volatile matter, naturally, will burn easier and will develop higher temperatures in the combustion chamber quicker than a coal containing less volatile constituents. Such a coal very likely does not require a very firm grinding and thorough mixing. Coals low in volatile matter, which, as a rule, burn slower and which reach high temperatures in the combustion chamber less quickly, must for the same reason be ground very fine, in order to obtain complete mixture. Besides, the combustion chamber in the latter case must be designed more carefully in order to maintain the temperature required for combustion. In this connection it must be remembered, that low grade fuels show the more the character of fuels low in volatile matter, the more ashes they contain (disregarding the moisture contents on account of the preliminary drying). Refuse of gas coal with 60 per cent ashes and with 30 per cent of volatile matter in the original coal, will, therefore, contain .6 x 30 or 18 per cent volatile matter. This refuse, therefore, corresponds to lean coal.

The high temperature obtainable with powdered coal acts favorably for its use under boilers. It is a well-known fact, that high efficiency and good operation of water tube boilers, fitted with traveling grates, is due mostly to high temperature of combustion caused by the radiated heat. The possibility, to expose a large part of the heating surface to the radiation from the hottest part of the grate, does not exist with powdered coal firing. Here the flame is not supposed to give up its heat directly by radiation or by convection to the heating surface, because, in this case, incomplete combustion of the coal dust would be the result. For this reason a return tubular boiler, supplied with a powdered coal installation, will have to be bricked up over its whole length, which, in turn, will diminish the action of the most valuable heating surface to a large extent. According to the experience, collected to date, preheating will hardly be avoided with this kind of boilers. There will then be the possibility of carrying out the combustion partly in the Dutch oven and partly in the tubes. If combustion takes place in the Dutch oven, no lining is required in the fire tube. With water tube boilers, on the other hand, the combustion must take place in the Dutch oven. This disadvantage is partly offset by the heavy eddy currents, which are necessary for powdered coal firing, and which increase the possibility of making use of convection. High ash contents will make, aside from the other disadvantages shown above, part of the heating surfaces useless, because they will settle on them and will cake. These cakes must be removed from time to time, while the dust deposits must be blown out in the usual manner. The liquid slag must either be removed as such or it must be granulated before removal, which can be done by counter-currents of the cold air required for combustion.

We will not deal here with the requirements to be observed for the refractory lining of the combustion spaces, but will only mention the fact that the ashes of the coal to be used have to be analyzed chemically, because the kind of refractory lining to be applied depends to a large degree on the chemical composition of the ashes. In general it can be said, that with a basic slag no acid material should be used and vice versa.

The advantages connected with powdered coal firing are as follows: The efficiency of the boilers will be higher than that of the boilers having hand-fired grates. The air excess can be lower, which reduces the stack losses. But, as was stated before, the oxygen content of the flue gases must be higher than that obtained in coal dust fired cement kilns (.5 to 1 per cent) on account of the safety of the lining, thus requiring practically the same amount of excess air as is required with chain grates. For this reason powdered coal will probably give no higher efficiency than the latter type of grates and it very likely will, on account of the high cost of grinding, be restricted to those types of boilers, for which chain grate stokers are out of the question, and which are the return tubular boilers, used extensively in Germany.

The readiness for operation is said to be larger with powdered coal installations than with any other type of firing. If the temperature required for the combustion of the fuels is once reached, a quick increase of the flame temperature is possible, but care must be taken that this temperature does not get so high as to destroy the lining. Readiness for operation is, furthermore, depending upon the moisture contents, upon the size of the walls, their tightness, upon the length of the shut-downs and upon the kind of fuel. A big advantage, which will be found with every powdered coal fire, is the completely smokeless combustion. Worth mentioning are also the small draft losses, because there is no resistance through the grate and the quantity of waste gases is small on account of the small air excess. This condition may be of large importance with heavy overloads and it may save a rebuilding of the stack. The higher temperatures will, in turn, cause heavier loads, thus either allowing the use of a smaller number of boilers, or preventing the installation of new economizers. Such conditions will have to be considered, whenever old overloaded plants are to be changed to powdered coal firing.

A regulation of the amount of coal dust required and of the necessary quantity of air is always possible within wide limits when the installation has been designed in the right way. This regulation may vary between 0 and 15 per cent of the normal capacity. The fire can be turned out at once, which, under certain circumstances, for instance, to prevent the blowing off of the safety valves, may be very important; this blowing off causes, according to recent observations, more losses than has been generally believed. Another big advantage is due to the absence of grates and of other movable parts within the combustion chamber, because all movable parts for a powdered coal installation are located outside of the fire zone. The transportation of the fuel to the burner by means of a screw conveyor, compressed air or blower, is comparatively simple. The main advantage, however, is due to the saving of labor. Although two men are required to operate the dryers and grinders for an installation large enough to serve 20 boilers, probably one or two men are necessary to take care of the boilers proper. These two men can also easily take care of the pumps and the water gauges. The operation of the furnaces is so simple that it can be thrust into the hands of unskilled labor. This would make the operation independent of the skilled boiler operators, which would be of advantage to the mines, which always have to suffer for want of good men.

These advantages are counterbalanced by very essential disadvantages. In the first place has to be mentioned the high first cost, which, under present conditions, amounts to over $250,000 for a tube mill with preliminary crushing and drying, having an hourly capacity of 3 tons, which would be sufficient for 10 R. T. boilers of about 325 square feet heating surface each. For a capacity of 6 tons per hour, this price would be nearly $500,000. This sum does not include freight for the machinery, erection and buildings. The operating cost is also high. It is composed of the cost of the power required for the crusher, dryer, grinder and transmission machinery, of the fuel cost for the dryer, and of the general operating cost, and of maintenance, interest and depreciation. To this have to be added the cost for removing ashes and slag, for repairing the firebrick lining and eventually the expenses for a better and more careful water cleaning, which is necessary on account of the higher boiler capacity. These are the reasons, that, as is said in America, a powdered coal installation operates efficiently only in such a plant where the daily coal consumption is about 100 or 120 tons.

Conditions for the introduction of powdered coal firing are not unfavorable when the power plants for mines come into consideration. These are mostly plants with a daily coal consumption of around 120 tons, where there is plenty of space at hand which can be used for the coal dust machinery. There are, furthermore, all the necessary repair shops so that no difficulties will be encountered if anything gets out of order. Especially the coal in the Ruhr basin is well suited for powdered coal firing on account of its gas content. Besides, nearly all the boilers in mine power stations are return tubular boilers, for which a grate equivalent to the traveling grate has not yet been invented. For instance, in the mining district of Dortmund, Westphalia, 68 per cent of the total number and 75 per cent of the stationary boilers are return tubular boilers. For these boilers coal dust firing will permit a much better utilization of the fuel. The main reason, however, which has the most weight in this connection, is the fact that enough coal dust is at hand at the mines, without having to resort to grinding. In some cases air separating will furnish between 50 and 60 per cent of coal dust per day, which up to the present time has been practically worthless. Part of it may be sold to foundries, part of it is used with the coking coal and gives coke of inferior grade, and some may be used with the boiler coal, decreasing the value of this coal as fuel. Where the dust is not aspirated it remains in the coal to be washed and goes with it into the washers, where it is an obstruction against washing. It finally appears further mixed with gangae, as mud in the sumps. This mud has, therefore, a much higher content of water and ashes than the dust aspirated before washing, and it is consequently a fuel of minor quality from a technical standpoint.

Experiments have shown that the dust which was aspirated in most cases has less than 1 per cent moisture, and seldom more than 1 per cent, but never more than 2 per cent. Dust with such a low moisture content can be ground without preliminary drying, thus saving at the mines the sensitive and expensive dryers. Of the aspirated dust, about 20 to 30 per cent have a fineness which permits a direct use in the burner, and the rest is in most cases fine enough that it permits the elimination of the rougher of a tube mill. This, also, means a decrease in first cost and in operating cost. Quick running mills give, under these conditions, a higher tonnage, and, with a certain definite capacity, it is possible to operate with a smaller number of mills.

Conclusion.

After a review of the development of the powdered coal firing in Germany, the installations and machinery are described which serve for drying and crushing or grinding the coal, for transporting it to the burners and the burners proper. Then follow data in connection with an efficient or inefficient use of the coal dust and data about the advantages and disadvantages connected with this type of firing. Finally the conditions are explained, which have to be considered when it is intended to install powdered coal plants at the mines.

SPEEDY ACTION URGED TO START BUSINESS AGAIN.

Speaking before the Pittsburgh Association of Purchasing Agents at the Ohio, Tuesday evening, J. A. Campbell, President of the Youngstown Sheet & Tube Co., made a straight-from-the-shoulder, shirt-sleeve talk on the difficulties of present business conditions and the necessity that something definite be done to correct the situation, if it is not to drag along from bad to worse for several years.

President Campbell said the situation would eventually right itself even though nothing were done. He declared, however, that the country could not afford to pay the price of such a solution. Radicalism, more government interference with business and possibly federal control in important lines with the inevitable attendant ills such as were seen during the war, would be the result, he asserted.

The speaker said that he had that day wired the president opposing legislation looking to the extension of federal control and uring the president's own slogan of less government in business and more business in government. He mentioned opposition in particular to the Frelinghuysen coal stabilization bill. President Sanborn of the Purchasing Agents Association later informed the speaker and audience that his organization that day had adopted resolutions opposing the Frelinghuysen bill and communicated them to Congress.

The steel-maker mentioned the absence of foreign trade, the improbability of any substantial revival in that quarter for some time and the handicaps being imposed on American industry by competing with the low priced labor of Europe. Much could be done to ameliorate this situation, he declared, by adjustments here at home.

In this connection President Campbell insisted that lower freight rates, permitting movement of commodities over the long hauls in this country and to seaboard points for export at fair charges and the adjustments of labor rates on a relatively equitable basis throughout the country, are absolutely fundamental to any attempt at correcting existing difficulties.

The speaker mentioned recommendations that he would make in this respect to Congress. These included repeal of the Adamson law, which he branded legislation to increase wages rather than to adjust working conditions; what amounts to discontinuation of the railroad labor board; restoration to the railroads of wage control, settlement between the government and railroads permitting repayment by the latter of advances made for improvements during the war in 15 annual installments and payment to the carriers of amounts due them from the government.

Much condemnation was voiced at the present impossible tripartite control of the roads by the managers, the interstate commerce commission and the railroad labor board. This situation was declared impossible owing to conflicts of authority and lack of coördination. If there must be a labor board let it be one representing the public only, it was urged.

Something must be done for the railroads and that quickly or important systems will be in the hands of receivers soon, it was declared. Nothing but speedy legislation unshackeling the roads will help. We can't wait with men walking the streets and another winter coming on, said the speaker.

The necessity of helping the farmer get his crops to market at a fair price so that he would be able to make his influence felt again as a buyer, was emphasized. Excessive freight rates have virtually cut the farmer from his markets or left him so little when he does ship that his purchasing power is practically destroyed. This was declared to be one of the most damaging features of the domestic situation.

President Campbell said he was opposed to a high tariff, but that people should be willing to pay some tariff for the privilege of living in a country such as this. He said labor is working in Europe for the equivalent of 10 or 12 cents an hour in U. S. money and that there is little spread between common and skilled labor rates there.

The fact that Germany is underselling U. S. in Japanese markets $20.00 a ton of steel was mentioned.

Pulverized Firing in Steam Generation

General Discussion of the Use of Pulverized Coal — A Typical Layout of a Successfully Operated Plant.

By F. J. CROLIUS,
Steam Engineer, Carnegie Steel Company, Munhall, Pa.

Philosophy of the Subject—Hazards.

PROBABLY the first thought that comes to the average mind when pulverized coal is mentioned, is its danger; and not without reason, for finely powdered coal under certain conditions is a very dangerous plaything—but only under certain conditions.

This fact is well known, but until recent years not well understood.

PREFACE.

Introduction.
The Philosophy of the Subject.
  a. Hazards.
  b. Safety.
Steps in the Development of Pulverized Operation.
  a. Failures and causes for failures.
  b. Successes and reasons for success.
Two Distinct Schools.
  a. Indirect firing.
  b. Direct firing.
Methods of Preparation.
Methods of Distribution.
Methods of Firing.
Combustion Chambers.
  a. Water cooled—slagging.
  b. Air cooled—non-slagging.
Boilers.
  a. Small.
  b. Large.
Costs.
  a. Installation—new.
  b. Application to the existing installation.
  c. Operation—new.
Economics of the Subject.
Reasons for the Choice of Pulverized Firing.
  a. Various items between the coal pile and ash heap.
Probable Applications in the Future.
  a. To existing small units.
  b. As auxiliary fuel.
  c. To future large units.
Conclusion.

The conditions under which it is dangerous, are diffusion in atmosphere unmixed with a non-combustible solid, or confined, as in a chamber or mine, mixed with an inflammable gas like methane, and under these conditions brought under the influence of ignition.

In cement plants, or mining concentrating plants, we find the conditions of non-combustible present—there the hazard is very low.

At the Universal Portland Cement plant, operating 28 pulverizers over a period of 12 years, averaging close to a ton of coal per hour, they actually tried to create a condition of explosion, but were never able to do so. These were aero pulverizers, direct fired on undried coal.

Stored coal will spontaneously burn and coke, but this is not necessarily a danger.

Conditions under which finely powdered coal is not dangerous is where it is not stored in bins, nor allowed to accumulate in inaccessible nooks, or where it is burned immediately as puverized, without allowing any chance of leaking out into a dust-cloud formation.

Where distribution is systematized, if the complete system is properly designed and adequately built and sealed, and the flow of coal through the system is continued uninterruptedly, there need be but little danger.

Where coal has to be dried before pulverizing, and most distributing systems require that the coal be dried, the drier itself offers the ignition point, where danger exists. Great care must be observed at this point in order to reduce the hazard to a minimum.

The entire safety of the pulverizing plant largely depends on the man tending the fire in the drier.

This entire subject of pulverized coal hazards has been carefully observed and analyzed by the Bureau of Mines; an excellent paper by Mr. L. D. Tracey of that bureau covers the finding to date so comprehensively that we can do no better than repeat his conclusions. They appear as follows:

Explosions have been more disastrous if they have happened in the buildings housing the pulverizing machinery.

Adequate ventilation is necessary to prevent the formation of dust clouds.

A mixture of .032 of an ounce of coal dust (just covers a silver quarter) per cubic foot may cause an explosion if ignited.

A definite amount of incombustible mixed with the coaldust will render it non-explosive — this depends entirely upon the ratio of volatile to total combustible. Naturally high ash coals and low volatile coals are lowest in the scale of explosibility.

Powdered coal bins should never be located near or above an active furnace.

Spontaneous combustion at or near the driers have been a frequent cause of fire.

"The rate of absorption of oxygen increases so greatly with the rise of temperature that the warming of coal by a steam pipe or boiler may enormously shorten the time necessary for spontaneous combustion."

Above 150 degrees F. the rate of oxidization is very rapid. This should be the maximum temperature of any coal delivered to a storage bin.

Investigation has shown these temperatures frequently exceeded.

Electric flashes will ignite a dust cloud and all switches should be safely outside the danger zones. The dangers from motors are so great that the

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Auspices Combustion Engineering Section, A. I. & S. E. E. Presented at Pittsburgh Monthly Meeting, May 14, 1921.

Bureau of Mines has classified motors into two classes—permissible and others.

Even the breaking of an incandescent lamp bulb may ignite a dust cloud.

There is, however, a solution to this apparent combination of hazards, as can be seen from this summary of conditions. It is merely a question of recognizing the fact that a hazard exists and preparing accordingly.

The psychology of the matter is the fear, or question of fear, that has surrounded pulverizing in general. Undoubtedly, this factor has retarded the development of pulverized firing as a power fuel, because, to many, this has seemed like a compounding of two dangerous practices. High pressure boiler operation has always been considered hazardous. Let us see what the facts are.

Safety.

Under the general head of safety we can investigate accidents in boiler houses, we can subdivide these accidents into classes and proportion the classes.

Investigation along these lines will show, if we take the largest industrial corporation as a criterion, that hazards, attendant upon boiler operation, are absolutely the lowest in actual percentage of all mill accidents.

As a matter of fact, the majority of accidents about boiler operations are minor cases. A small proportion only being lost-time cases. And these cases the application of pulverized firing will very greatly reduce.

The actual percentage of accidents occurring in the boiler houses of one of the largest plants in the Steel Corporation, over a period of ten years, was only one-hundredth of one per cent of all mill accidents—while for the entire corporation the percentage stood at eight-hundredths of one per cent (.08%).

Surely not very dangerous practice.

While there have been a number of accidents, some serious, occurring in and about the pulverizing plants themselves, I have never heard of a serious accident in a boiler house where pulverized coal is burned as a fuel.

Steps in the Development of Pulverized Operation. Failures and Causes for Failures.

In 1846 patents were issued in England for a pulverizer and a pulverizing combination under boilers, which if installed according to the patent specifications under a modern boiler would have given successful results. But the boiler was of the 1846 vintage and the laws of combustion were then not so well developed.

From that time forward, frequent attempts have persisted, special boilers, like Bettington, have been designed—but the many attempts under boilers were failures.

The probable reason for most of the failures is not difficult to trace; it was the size of the boiler and the character of the setting plus a lack of knowledge of combustion.

If we merely glance back twenty years, we will find a 250-hp water-tube boiler considered mammoth. And if we attempt to measure the size of the combustion chamber we will find a micrometer necessary—there was no combustion chamber as we now understand one. Today we design a combustion chamber, and then build a boiler around it.

The operating conditions which resulted in failure were definitely—slagging upon tubes, destruction of brickwork, cost of maintenance, and expense of installation.

Early experiments were naturally applied to the smallest unit available, as the experimental cost would then be reduced. But the small boiler and setting was just the unit which should have been carefully avoided. I have no hesitation in saying that if the early experimenters had started with the new Ford boilers, with their adequate combustion chambers, they would have been rewarded with success.

Proof of this exists in several directions; cement kilns with their enormous chambers, enormous in relation to fuel requirements, were successful from the start.

Open-hearth furnaces, although having a smaller proportionate chamber, experience no difficulty from a combustion standpoint. Their troubles lie elsewhere.

Continuous heating furnaces show beautiful combustion. And so on.

Success and Reason for Success.

But all of that is of the past; pulverized firing in the future should record nothing but success, at least there is no reason why it should not.

It is no longer an experiment—a number of men, by their untiring energy, patience and resource have developed pulverized firing into a science. As engineers, we owe them a tribute; as operating superintendents, we owe them a vote of thanks; as executives, we can afford to reward them with an annual bonus.

John Muhlfield you have all listened to; to him and his associates, Mr. Carachristi and Mr. Savage, our debt is large.

To John Anderson of Milwaukee, whose plant at Milwaukee is now the Mecca of power-plant engineers the world over.

To Mr. Turner of the Ford Company, and your own Mr. Ladd, who have had the courage and resource to visualize their imagination into the present wonderful Rouge River installation.

These and many others have laid the secure foundations upon which an ideal edifice is arising and will continue to rise.

The Locomotive Pulverized Equipment Company, the Combustion Engineering Corporation, The Fuller-Lehigh Company, The Bonnot Company, The Quigley Company and the Aero Pulverizer Company are a few of the pioneers who have met the problems, and have "licked them," to use that popular expression.

A few moments ago we spoke of failures; failures they were, but the biggest failure was small in comparison with the present success.

A visit to Milwaukee will silence the worst skeptics. It is unnecessary to discuss in detail that remarkable development—it is too well known to require comment—sufficient that a kilowatt is there produced on 19,000 Btu.—the lowest recorded from any power plant.

Those of you who are familiar only with steam generation from blast furnace gas, aided and abetted by occasional hand-fired run-of-mine coal, should spend a day at River Rouge. You will awake to find yourselves in another world.

Visit the Bethlehem Steel Company at Lebanon; the M., K. & T. R. R. at Parsons, Kansas; the Puget Sound T. L. & Power Co. at Seattle; United Verde Ext. Mining in Arizona, Nevada Consolidated Mining in Nevada; A. Hanna Mining Company at Lytle, Penna., and the Allegheny Steel Company at Brackenridge, Pa.: the Erie City Iron Works, or at Homestead, there you will find steam being generated with a variety of boiler types.

Edgemore, Ladd, O'Brien, B. & W., Stirling, Heine, Rust, Wickes, Erie City, Cahall, and Return-tubular—in sizes of units ranging from 150 hp to 2,500 hp, burning every character of coal from Nanaimo slack of 9,300 Btu., with 28 per cent ash, anthracite slush of 13,000 Btu. with 24 per cent ash; Illinois slack with 10,000 Btu. with 14 per cent moisture to good Pittsburgh steam coal.

You will find boilers being operated at any ratings desired, at efficiencies irrespective of coal analyses, averaging about the 80. per cent mark.

It may also be of interest to mention that the General Electric Company was one of the pioneers in the field (having had in its Schenectady plant one B. & W. boiler equipped and operating for many years. They have issued test data from which successful conclusions may be drawn.

These plants are successful—and very successful.

Two Distinct Schools.

Many engineers have attacked their problem in many different ways, but the result of these various lines of attack have developed into two schools of pulverized operation.

a. The indirect or concentrated preparation plant.

b. The direct fired.

The indirect method was the logical first step in the application of pulverized fuel under boilers—it presupposes the existence of pulverizing equipment already delivering pulverized fuel for some metallurgical purpose in a plant, and the extension of this pulverized fuel to boilers, already existing.

In this method the coal is usually prepared in a central pulverizing plant, conveyed to the boiler house and distributed to the boiler furnaces.

Methods of Preparation.

Preparation involves unloading the raw coal, elevating it to bins, removing the surface moisture by heating within a revolving indirect-fired drier, elevating the dried coarse coal to the dried coal bins—pulverizing the dried coal in any of the many types of pulverizers; roller, ring-roll, ball or tube—such as Raymond, Bonnot, Fuller, Hardinge, or Kennedy; exhausting the finely powdered coal from the pulverizer into a separator, from which it is conveyed by screw or air to points of consumption. It will be noted that these enumerated activities require a definite number of motors per unit of operation, in no case less than six (6), usually more.

As mentioned, there are many kinds of mills, each with their firm adherents and also their firm antagonists; we need not enter into that discussion, the comparative data can be assembled by any engineer. Suffice to say, those mentioned are all commercial successes, they do their work, and all have their troubles.

The crux of the discussion has centered about the Method of Distriubtion.

Fundamentally there are three (3) methods of distribution—screw conveyor, volume air at low pressure, high pressure air.

Screw conveyors are costly to install, maintain and operate. Volume air at low pressure raises the question of a possible combustible mixture, and require much power.

High pressure air costs money to install and operate.

Holding no brief for any one of these methods, the latest development which seems to offer the approach to an ideal, is the combination of high-pressure aeration with the displacement pump developed in the Fuller-Kenyon combination. This seems to combine the elements of low cost, low power, flexibility and reliability.

Method of Firing.

Having brought the pulverized coal to the point of consumption, it is now a simple matter to fire it. You are all familiar with the various types of feeders, controllers and burners, all have been pictured, discussed and featured. All are good, but none are automatic. Most of them are based on the same principle, a small motor driven screw feed, connected under a bin and supplied with an air current.

Direct Method.

In the direct method of pulverized application to boiler firing, the pulverizer is placed directly at the boiler, the existing raw-coal handling equipment is utilized, the coal is fed to the pulverizer undried, and is exhausted directly into the boiler furnace or combustion chamber. There is no hazard from driers, no hazard from bins, back fires from momentarily unbalanced pressure; there is no storage of gun-powder, to quote Sam Wales.

Instead of a minimum of six motors being required for the operation, one motor or turbine may suffice. The power which is required to drive the exhauster fan alone in the indirect method, is almost enough to perform the entire operation alone in the direct method.

The burner and ignition problem is the same in both methods but the direct method is more susceptible of automatic control. Such is now applied. The aero pulverizer has been the unit most used in direct firing. The Hagan control has been applied to this.

Comparatively little development work along direct firing of boilers has yet been attempted. The most obvious reason, in my mind, has been the sub-conscious thought that pulverized firing was a very mysterious and difficult engineering feat—and must not be attempted without spending a fortune. It may be that suitable equipment has not been available, or the fact was not known that 95 per cent—200-mesh undried coal was not needed.

However, its manifest advantages warrant considerable development, and such development work is now in progress.

Combustion Chambers.

The most important feature and the feature upon which successful operation entirely hinges is the combustion chamber.

Here again, we find two schools.

a. Water-cooled.

b. Air-ventilated.

The water-cooled chamber seems to have been a development made to overcome the lack of cubical contents possible under small, badly set boilers. This is a development of the Erie City Boiler Works—where one is in operation.

Certain claims have been made for it as to capacities, and many tests have been run to verify these claims, but since the character of wall construction affects in no way the fundamental laws of combustion, which are primarily based upon temperatures, air dilution, velocities and the resultant time element, I feel that much is left to be proved. Whether or not the saving in annual repairs will repay for the large investment is a matter of determination.

The usual construction of furnace is an air-ported or ventilated structure—this is nearly universal practice.

The fuel is admitted either horizontally or vertically or at an angle.

The preference as to the method of admission depends upon local limitatoins entirely, combustion results are uniformly good with all, provided the operation is proportional to the capacity of the combustion chamber. There are fewer operating difficulties with vertically fired furnaces—boilers at Milwaukee kept on the line six or eight weeks.

There is still considerable practical experimental work in progress toward the development of an ideal furnace, and such research will undoubtedly continue as long as man is ambitious.

Boilers.

In the discussion of generating units, I have divided all boilers into two classes: a. small boilers; b. large boilers.

By small boilers I mean all units below 500 hp; by large boilers I mean those units above 500 hp.

This is an arbitrary and a very rough classification, but it represents generally a period in the history of water-tube development previous to (1904-1910) and from that time forward.

The general scheme of operation of small boilers was quite different from the present methods of operation of larger units.

The era of many small units, natural draft, was more or less a period of hit and miss low-rating operation, involving expensive coal handling and ash conveying, a perfect picture of unregulated, unrecorded, unanalyzed operation in the hands of a multitude of relatively low-paid pactical firemen and laborers.

Efficiencies were conspicuous by their absence, and the efficiency engineer was as unwelcome as the plague.

The large boiler changed all this. Today we have, as standard practice:

Adequate combustion chambers.
Forced draft air supply.
Correct feed-water regulation.
Flexible damper and fan regulation.
Proper conditioning of make-up water.
Practical flow-meters for water, steam and air.
Practical recorders for gas analyses.
Combustion data and combustion schools, accessibe to all.

In fact, a concentration of efficient operation in the hands of experts whose evident aim is the reduction of human hand power to the very minimum.

Where formerly it required one man to produce 250 hp. today one man can produce 5,000 hp.

Where formerly the annual cost, at 50 per cent efficiency, averaged well over one hundred ($100) dollars per hp year, today at 80 per cent efficiency that hp can be produced for $50.

And right here pulverized firing will play its important part.

Numerically the small boiler demands attention, for more steam is still being produced in small boilers than in large boilers; expressed in round numbers, some 100,000,000 tons of coal are consumed in small low-efficiency plants, as against 75,000,000 tons in large boilers and the comparison of cost between them stands safely at a three to one ratio against the small plant.

Here, then, is the immediate field for pulverized application—for remarkable as it may seem, the actual efficiency obtainable in any type or size boiler, using any kind of coal varies but slightly; when the setting is properly proportioned.

The small boiler can be made as efficient as the large.

Costs.

This naturally depends largely upon the size of the new installation, and the choice of equipment selected to do the work. On this score, there are many opinions, with which we will take no exceptions. In general, it may be said that a complete plant, including all coal handling and pulverizing equipment, boilers, furnaces, fans, motors, etc., can be erected at about the same investment cost as the capacity stoker equipment would cost. This applies to an indirect fired plant.

The cost of re-equipping existing boiler plants can be made less on pulverized basis, and is usually more practical, as the forced air supply, incident to pulverized firing, vastly simplifies the question of a change to forced draft.

Careful analyses of many comparative operations indicate a lower cost-operation for pulverized firing than for stokers.

As these comparisons have quite largely centered about central station practice, wherein stoker practice has reached its maximum, I am rather inclined to believe that average comparisons which included stoker practice in average industrial operations, would very strongly favor the pulverized operation.

A comparison of costs covering a 20,000-hp operation appears as follows:

	A	B	C
Boilers	$ 330,000	$ 330,000	$ 330,000
Settings	190,000	240,000	240,000
Stokers	190,000	......	......
Pulverizing equipment ..	......	369,000	80,000
Bins	130,000	140,000	130,000
Buildings	200,000	170,000	200,000
	$1,040,000	$1,249,000	$ 980,000
Operating cost—not including interest on investment, taxes, depreciation, etc...	$ 55	$ 49	$ 48.70
	1,100,000	990,000	920,000.00

As a justification of any economic theory or suggestion it is often fruitful and interesting to cast it into perspective against the total economic background. Especially is this true of coal.

As an industry, the mining, the transportation and the consumption of coal, one of our most useful and valuable sources of natural wealth—as an industry, nothing but coal could bear the burden of inefficiency and waste which characterizes the course of this product from its origin to its destruction.

It is a major subject in itself.

Coal has aptly been called "Black Diamonds"—and the term is most appropriate—not because of the color significance, because all coals are not black—some are gray, and others brown—but rather on account of the somewhat less obvious analogy—that to the diamond itself. Diamonds are precious because they are a luxury, and they are a luxury because they are expensive; one of the vital reasons why they are expensive is because of the very small proportion actually recovered in the process of making them valuable.

It is in the relation of wastes of both diamonds and black diamonds that we find the real points of analogy.

There are approximately, as applied to our problem—

8,000,000	hp in central station power plants 20 per cent mechanical equivalent
10,000,000	hp in industrial low-efficiency plants 3 to 8 per cent mechanical equivalent
8,000,000	hp in industrial higher-efficiency plants 8 to 15 per cent mechanical equivalent

These plants consume nearly 175,000,000 tons per year, more than 25 per cent of the total coal mined in this country.

More than 120,000 men are employed in the steam plants
More than 170,000 men are employed in the mining of coal
More than 130,000 men are employed in the transportation of it

If all these plants are equipped for pulverized firing, at least it would save:

30.000.000 tons worth $4 per ton........	$120,000,000
50,000 employees at $2,000 per year...	100,000,000
200,000 empty return car miles at 10c..	20,000,000
	$240,000,000

These figures are, of course, approximations.

The cost of equipping the average boiler will not exceed $20 per developed hp.

$$10{,}000{,}000 \text{ hp} \times \$20 = \$200{,}000{,}000$$

In these days of extravagance and waste reductions, there is no more fertile field and none more sure of adequate returns.

Economics of the Subject.

Let us glance at the distribution of the coal mined last year in this country alone; its allocation will indicate our problem.

600,000,000	tons mined
150,000,000	tons used by railways
100,000,000	tons used by ships and exported
100,000,000	tons used in domestic homes
75.000,000	tons used in coke
425,000,000	tons
175,000.000	tons used in power plants; large and small
75,000,000	tons used in 20 per cent efficient power plants
100,000,000	tons used in 3 to 15 per cent efficient power plants

The cost of producing power in a small plant—that is:

Below 500 hp is about 4 times the cost of a 10,000 hp plant
Above 500 hp is about 3 times the cost of a 10,000 hp plant
Above 1,000 hp is about 1½ times the cost of a 10,000 hp plant

and of this total cost, items of coal and labor are a rapidly ascending curve in inverse ratio with the size of the plant.

Numerically the small, low-efficient, high-cost plants are decidedly in the majority and these should be the logical points of attack.

The general impressions have been that pulverized firing was not practical in plants below 2,000 hp. Nothing could be further from the truth, for exactly here will the greatest and most immediate and permanent economics be found to justify the change.

The average plant below 2,000 hp is using not far from seven (7) pounds of coal per hp hour, and the labor and coal items approximate nearly 80 per cent of the total cost not far from $120 per hp year.

Pulverized firing will cut these costs in half.

This general thought that small plants were not susceptible of this development has probably gained currency because of the excessive costs that have surrounded pulverized installations.

But central station ideas need not necessarily be applied to the small plants, nor need central station investments be invited.

Concretely, it is quite possible to re-organize a small plant of say four 250 hp—500 hp boilers, rebuild the furnaces so that they are adequate to burn pulverized coal efficiently, use much or all of the coal and ash-handling equipment with slight changes—install pulverizers, burners, feeders, fans and regulators—all at a cost well within the means of any company operating such a plant.

And when a small plant is so rebuilt, its operating labor costs, coal and overhead costs will compare very favorably with the efficient large plant.

Ultimate Possibilities.

Up to this point we have confined our discussion to stationary boilers; that problem is big enough in itself; but, if a slight digression is permissible, another most important phase of steam generation will be mentioned.

The locomotive is a power-plant and as such should not be lost sight of.

We will confine ourselves to the discussion of the American railroad as the statistics are more comprehensive.

Nearly 150,000,000 tons of selected coals are now destroyed annually in the 65,000 locomotives on our American rails—we say destroyed advisably, as the net mechanical equivalent received from this coal averages below 5 per cent. This low recovery is due to the combination of mechanical elements which go to make your locomotives, plus the difficulty of keeping these elements working even at the average efficiency. The boiler and furnace taken as a unit average closely around 50 per cent efficiency.

In other words, we find more than 50.00,000 tons of selected coals annually wasted and a good substantial part of the other 100,000,000 tons are burned just hauling this wasted third, and hauling back empty the millions of cars that carried the waste tons.

If this wasted third at $4 a ton could be deducted from the debit side there would be $200,000,000 to add to the net annual earnings of the hopelessly distressed United States Railways System. This 30 per cent increase upon the present annual $700,000,000 would be of tremendous help to the 175,000 miles of road now in receivership or approaching receivership.

If, instead of "selected coal," the locomotive could be fired with ordinary grade slack available at its nearest point, at least, $1 per ton cheaper, another $150,000,000 could be saved.

By pulverizing this could be done.

It has been shown that the larger power-plants convert nearly 20 per cent of the heat value into actual mechanical equivalent. It has also been said that the locomotives destroy nearly 150,000,000 tons annually, converting less than 5 per cent of this into mechanical equivalent.

This means that every ton of coal fired in a power house equals four tons fired in a locomotive.

Visualized inversely, this would mean that our powerhouses and industries would require over 700,000,000 tons per year, if the same character of operation obtained that now penalizes the transportation plants.

Is it any wonder the railroads are having a hard time to live?

In view of the fact that this accumulation of waste value over the next ten years will approach a total running into billions when you include coal, transportation of loaded cars and empty returns, wages, repairs, etc.—it would look like an excellent investment to hazard the little money required on what little experimenting is necessary to apply pulverized firing to locomotives.

The problem presents no very great difficulties and direct firing will find its logical development. The total cost of equipment for enough locomotives to handle all traffic on this revised basis should not exceed $350,000,000.

The Ideal.

Often times we are asked our reasons for the choice of pulverized firing and we reply, "Because it approaches the ideal."

You have all been in an average power house—you have gone through for an inspection, or, perhaps, it was necessary to investigate an accident or some safety recommendation, and you have noted the evident pride which was noticeable everywhere about the engine room and its appearance, in fact no structure could be more beautiful, architecturally, than the turbo-room of the modern power house like Philadelphia Electric at Chester, Colfax and Delray and dozens of others.

And, as you looked about you probably failed to notice that you weren't urged to be shown the boiler room. And, if you were shown the boiler room, it was not the same thing of joy that you found the engine room to be—it was just the boiler room, the necessary evil where millions of dollars, yes, hundreds of millions of dollars have been and continue to be wantonly wasted every year—just the boiler room, where a lot of grimy, dirty heroes eke out a miserable existence trying to interpret a lot of mysterious instruments into terms of thermal efficiency.

And then you saw the ash cellar, that bourne from which no traveler returns "clean or dry;" that undesigned court of last resort where humans still perform the labor under the worst conditions it is possible to imagine. The ash cellar—depository of more waste wealth than the total value of all gold mined last year. (It is a fact that I have analyzed ash being carted away from big buildings in New York at a cost of about two dollars a ton which carried a higher percentage of fixed carbon than many western coals.)

I am speaking of the ash cellar in the average boiler house, but not of the ash cellar in a pulverized firing house. There, there is no ash cellar, and instead of being reluctant to show visitors the boiler house, or the ash cellar, that is the point of greatest pride, for it is the point of greatest comparison, as likewise the point of greatest saving.

And so, if the adoption of pulverized firing did nothing else, the elimination of the ash cellar, the ash problem, and the ash wastes would amply justify the method—for the engineer would have taken one step nearer to his ideal.

Most papers on pulverized firing have gone to elaborate lengths to prove higher efficiencies for this method of firing than for stoker firing. Numerous tests have been cited, showing such dizzy heights of efficiencies that you have all gasped in amazement. Such arguments have never interested me, except in a purely academic way, for I have seen many tests, and such arguments are a mere begging of the question. With your kind permission, as engineers we will omit the question of tests, and by means of a series of Socratic questions, see if we can possibly justify pulverized firing otherwise.

First, what would constitute your ideal power house; each of us who have to do with power houses must have formed an ideal.

If I may answer for myself and for you, the answer would appear something like this:

1. A control board so automatic, so flexible, so fool-proof, so safe that a high-school graduate could distribute the total load without the possibility of an error.

2. A generator, or generator capacity, which would deliver the maximum and minimum load requirements at practically a constant efficiency, automatic as to controls, and absolutely reliable.

3. A turbine or turbines which would operate on the minimum water rate over all loads, in which there could be no blading, or bearing, or governor troubles.

4. Auxiliaries so well proportioned and so well designed that the main units are adequately served, and at the same time there is maintained an ideal balance throughout.

5. Boilers, furnaces, coal handling equipment and house design so flexible that—the load on the turbine will be supplied with an automatically controlled supply of an exact temperature and pressure steam; steam generated in boiler units of such design and size that a maximum output can be obtained from a minimum hp rating, in boiler furnaces of adequate design to develop the entire Btu. value from the most avaliable coal at that particular point. All movements of coal from the car or barges through the house to the completion of combustion shall be automatic, with likelihood of breakdown or interference reduced to the minimum, said movement and manipulation to be performed automatically and with the smallest number of human operatives.

The above total of work to be done with the least capital expenditure, to the end that interest on investment and depreciation items may harmonize with the lowest Btu. cost per kw hour produced.

Does this sound to you too ideal?

Now that we know what we want, we will go after it, and we will start at the coal-pile end.

What are the greatest losses? A glance at a series of heat balances and test sheets will show. The stack loss and the ash-pit losses.

When do these losses occur? The stack loss constantly but worst at cleaning periods.

What does the stack loss total?

In a 1,000 hp boiler, stoker-fired, the average ash drawn will contain 25 per cent unburned carbon, which means that 2,800 tons of ash must be handled per year and that 570 tons of carbon are lost.

In a 1,000 hp boiler, stoker fired, the excess air will average 50 per cent above the theoretical for combustion, which means that 131,000 tons of needless air are heated per year, and at least 4,000 tons of coal are wasted doing it.

Magnified into national losses, this means that more than 50,000,000 tons of coal are wasted annually heating excess air. About 20,000,000 tons of carbon equal to 30,000,000 tons of coal are lost through the ash pile.

If the coal fired in this country in steam plants and locomotives were pulverized, the loss due to excess air could be cut in half, and the loss due to unburned carbon in the ash eliminated.

Such a revolution would save some 80,000,000 tons of coal worth $400,000,000. As only about 15,000,000 tons of coal are annually fired in pulverized form. At this point, I would like to refer you to a number of exhibits furnished by Mr. E. G. Bailey, an engineer whom most of you know has specialized in this field of investigation.

Just now we stated that ash-pit losses were highest at cleaning periods, and Mr. Bailey's charts prove that excess air losses are also highest at this period. Consequently, it must follow that the lower the number of cleaning periods, the lower the losses.

Pulverized furnaces have no cleaning periods, or can be so designed, but Mr. Bailey's charts show the reverse where the stokers are used.

It is not necessary to detail other furnace and boiler losses; there is small difference between radiation, soot accumulation, etc., in stoker firing and in pulverized firing.

We have all heard a lot of the glittering generalities about the possibilities of this system or that system—we have made tests for efficiency, and we have carefully scruitinized the many tests made by other people, but all that does not afford any of us much comfort in the solution of our own particular problem.

We all know where we would like to arrive—but to find the starting point is a most difficult matter.

With your permission, I will give two concrete applications, either of which may serve as your "starting point."

Please understand that efficiency in either of these illustrations is not the mark we're shooting at—our most obvious aim is immediate reduction of total operating costs, increase of capacity, reduction of labor without huge appropriations. We will consider efficiency later.

The first problem is concerned with an old boiler house consisting of twenty (20) aged B. & W. type boilers (250 hp) fired by three different types of obsolete stokers—all natural draft—developing approximately 3,000 hp hourly at a yearly hp cost of nearly $100.

Coal handling, ash handling and producing labor charges were out of proportion to the product delivered. The best thing to do, of course, is to scrap the entire equipment, and replace it with new boilers.

With this thought in mind, estimates are made, bids are received and we find that it will cost about $300,000 to do the job. This means an appropriation, which under the existing trade conditions is open to considerable delay.

The immediate solution is to concentrate upon the fewest number of selected boilers; equip these with combustion chambers of sufficient capacity to operate at high ratings, that is, high in relation to former operations; install the cheapest available pulverizing equipments and then scrap the remaining units.

Practice has shown that six (6) boilers so equipped will deliver the total amount of steam—at a total cost for one year of about 60 per cent of former costs.

To do this reconstruction complete, costs total less than $30,000. You can all figure the return on the investment for yourselves.

The second problem had to do with a large plant operating a large number of scattered boiler houses, inter-connected with steam lines—all stoker fired, all mechanically equipped for coal hoisting and conveying, ash-handling, etc., but all boilers limited in their capacities by the size and character of their stokers, and by the natural draft limitations from which most plants suffer.

Fortunately, among this group of boiler houses was one house of ten (10) 1,000 hp boilers not very old.

Analysis showed that these ten boilers could be re-equipped to produce the total evaporation required to operate this plant, and the savings would warrant whatever types of pulverizing equipment this 17,000 hp production would demand.

Analysis of the factors comprising the charges against coal and ash handling from the yard to the yard may be of interest with a comparison of like charges with pulverized equipment:

	Former Per Ton	Pulverized Per Ton
Yard switching	$ .22	$ .22
Coal unloading and distribution	.23	.03
Firing	.17	.01
Ash handling	.26	.02
Repairs to equipment	.10	.07
Power, stokers, hoists, conveyors, etc.	.105	.00
Power pulverizers, exhausters, etc.	...	.22
	$1.085	$ .57

Estimates of various types of pulverized equipment together with the rebuilding of boiler furnaces, etc., indicated a cost ranging from $150,000 to $350,000. Between these two figures there is a wide latitude in selection of standard equipment; any combination of which can be depended upon to produce this evaporation at least the same rate of efficiency as present operation.

You can all figure the saving effected by multiplying 200,000 tons by $.51.

Pulverized Firing as an Auxiliary or Emergency Fuel.

Iron and steel mill practice has witnessed a broader application of waste heat utilization than found in any other industry. This is, of course, natural, as there are here found more waste heats to utilize than elsewhere.

Among the various types of waste heats, that from the blast furnace plays a leading part, and has been more consistently studied and developed than any other. (Apologies to Mr. McDermott of the Illinois Steel Company.

Blast-furnace gases are essentially a low quality, large volume problem.

The solution has been intimate ignition surfaces, low velocities through ample combustion chambers. Control of the excess air supply, through effective regulating devices has been found imperative.

Where the combination of the above elements has been assembled, remarkable results have been obtained. Plants are now operating on blast-furnace gas with a constant CO_2—25.5 per cent; steam pressure a constant 250 pound; steam temperature a constant 560 degrees—superheat invariable, and the furnace pressure a constant ZERO.

Such operation, however, implies a fairly constant supply of gas at nearly 3-inch pressure.

In many blast-furnace operations, electric power is developed to meet an outside constant load, this in addition to the usual gas which is required for furnace operation, blowing, stoves, pumps, etc. As blast furnaces are far from perfect operating units—due to internal conditions—(variables), the supply and pressure of gases will fluctuate rapidly and seriously.

This fluctuation is usually taken care of by the use of an auxiliary fuel. This fuel may be coal, hand-fired or stoker, coke-dust or tar, or pulverized coal. Pulverized coal is nearly ideal for this purpose.

Pulverized coal can be safely carried in suspension in a volume of air equal to about 25 per cent of that required for combustion.

A cubic foot of such mixture is almost equal to a cubic foot of average unwashed blast-furnace gas—about 90 Btu.

In other words, the combustion problem, as to ignition, furnace volumes, carried over incombustible burners, volume air supply are so similar that the combination is an excellent solution of an auxiliary fuel for this purpose.

The large Ladd boilers at the Ford plant in Detroit, so equipped, will furnish a wonderful demonstration of this practice.

Auxiliary Fuel in Central Station Practice.

Central station practice is essentially a peak-load operation.

To insure against this peak-load maximum, greater than average stoker and fan capacity must always be provided, maintained and carried as investment and depreciation.

The only limit to boiler capacity seems to be grate area, and the limit of efficient operation seems to be the amount of coal per square foot of stoker area which can be burned with a maximum blast pressure and still keep the fuel on the grates and not slag tubes, etc.

Stoker performance seems to have nearly reached its limitations.

Pulverized fuel offers an excellent field for development in this line.

This seems to be the opinion of very conservative engineers who have given the subject close thought.

There are many other fields in which some such combination may work out advantageously—various applications will suggest themselves to your various minds.

Among others, stand by boilers for hydro-electric plants

In conclusion let us review.

Pulverized coal was originally an ideal, and like any other ideal will persist. Rudimentary chemistry taught us that fuel combustion was clearly imperfect reactions—and the farther away from the atom we got, the more imperfect was the reaction to be expected.

Conversely, the nearer to the atom we brought our fuel the more nearly would we approximate perfection.

Pulverizing was the method of the laboratory calorimeter.

But in the laboratory costs are not a factor, while in industry, costs are the base of the pyramid.

Naturally, the application of a costly process, for pulverized fuel has always been relegated to that class, was first considered in processes or industries where fuel costs were relatively small, and has slowly invaded other fields more recently opened up by rising costs of labor and fuel.

Pulverizing is not a new art in the mining industry or in cement manufacture—there it is a standard practice, and has been for years.

Nor is there any novelty in its application to open-hearth, puddling furnaces, or heating furnaces.

I have referred to other industries to show the psychological connection between many of the present pulverized systems installed under boilers and their origin.

Metallurgical operations frequently require very close specifications in fuel and its preparation, and to overcome those narrow limitations, a variety of systems have been developed.

When boilers were to be equipped, such complete systems were naturally commandeered. It was not a question of equipment to do a given work—it was an equipment which was known to do a certain work of an apparently similar kind. Engineers are human, and like most human beings, they follow the line of simplest attack.

Now, in the metallurgical field, costs could be high and still not be prohibitive, because pulverized fuel had only to compete with other expensive applications, such as oil, tar, producer gas, by-product gas, etc., and the fuel was only a comparative item in the production of a profitable tonnage. But under the boilers, the competition of mechanical stokers develops an entirely different picture. The entire job must be done cheaply for mechanical stokers are now very efficient.

Just at this point we find the line of departure between pulverized coal in metallurgy and pulverized coal as a power fuel.

Over eighty years ago patents were allowed on a practical application of pulverized firing to boilers; twenty years ago complete plans were drawn for larger commercial operations.

PRODUCTION TOPICS

WAGES IN THE UNITED STATES AND FOREIGN COUNTRIES.

(Prepared for the use of the Committee on Ways and Means, House of Representatives.)

IRON AND STEEL INDUSTRY.

UNITED STATES.

Average earnings per week of furnace and mill workers, 1920.*

Blast furnace and rolling mill workers................$43.12

Rates per ton for workers in bar iron plants.†

Puddling, 1895	$ 5.50
Puddling, 1920	16.00

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*The Iron Age, 1920.
†U. S. Tariff Commission survey, 1921, p. 20.

ENGLAND.

Rate per week (47 hours) for common labor, 1921.‡

Common labor ....70s. 4d. = $12.52

Unemployment decreased 1.3 per cent in month of December, 1920.

Short time is general throughout industry, many works being closed down.

Rates per ton in bar-iron plants, 1907, 1913, and 1920.

Puddling:	
1907°	$2.33
1913§	2.74
1920°	$7.50-8.27

Rates per week in various iron and steel trades, 1920.¶

Occupation.	Location.	Month.	Rate. s.	d.	
Iron molders	Carlisle	October	88	10½	=$15.46
Do	Huddersfield	Do	90	6	= 16.05
Do	Otley	Do	91	8	= 16.25
Do	Newport	September	100	0	= 17.40
Coppersmith (ship)	London	July	105	0	= 18.27
Pattern makers	Edinburgh		96	9	= 16.85
Fitters	Shops Great Western R. R	August	99	7	= 17.33
Turners	Do	Do			
Smiths	Do	Do			
Coppersmiths	Do	Do			
Boilersmiths	Do	Do			
Fitters	Todmorden	June	88	3	= 15.35
Turners	Do	Do			

¶Department of Commerce.

Rates per week for women and girls in malleable iron plants, 1920.¶

Occupation.	14 years old	18 years old	20 years old
Molders	$3.58	$7.20	$8.00
Dressers	3.58	7.20	8.00
Foundry wheelers	3.58	7.20	8.00
Sand blasters	3.58	7.20	8.00
Core makers	3.58	7.20	8.00
Examiners	3.58	7.20	8.00
Sand wheelers	3.58	7.20	8.00
Emery wheel dressers	3.58	7.20	8.00
Power pressers	3.58	7.20	8.00
Polishers	3.58	7.20	8.00
Capstan lathe workers	3.58	7.20	8.00
Hand pressers	3.36	6.65	7.42
Machine workers	3.36	6.65	7.42
Varnishers	3.36	6.65	7.42
Rough warehouse workers	3.36	6.65	7.42
Bronzers	3.36	6.05	7.42
Wrapping workers	3.15	6.40	7.20
Warehouse workers	3.15	6.40	7.20
Lacquerers	3.15	6.40	7.20

¶Labour Gazette, September, 1920.
‡Hugh D. Butler, American trade commissioner.
°U. S. Tariff Commission survey.
§Commerce Report, June 27, 1913.

Minimum rate per week (48 hours) in Birmingham wire-working plants, 1920.¶

Occupation	Per Hour s.	d.	Per Week
Wire workers	1	8	$15.30

¶Labour Gazette, August 1920.

FRANCE.

Rates per day in iron and steel mills 1913 and 1920.¶

	1913 Francs	
Highly skilled workers (piecework)	11.0–15.0	$2.12–$2.90
Skilled workers in various lines	8.0–10.0	1.55– 1.93
Ordinary workmen or helpers	3.5– 4.5	.68– .89
	1920 Francs	
Highly skilled workers (piecework)	25–40	$2.00–$3.20
Skilled workers in various lines	16–19	1.28– 1.52
Ordinary workmen or helpers	12–16	.96– 1.28

¶J. F. Butler trade commissioner.

Highly skilled workers paid on a piece basis received from 11 to 15 francs per day in 1913. These men now earn from 25 to 40 francs a day. The Comité des Forges de France the central organization of the French iron and steel industry which furnished the above information pointed out that under present economic conditions it is necessary to revise wages constantly. Under these circumstances it is impossibe to predict the level which may be reached before wage conditions become stable.

Rates in Grenoble snap-fastener establishments, March 1, 1921.

		Francs		United States Currency	
Factory girls	per day		7.76		$0.54
Factory women	do.		9.36		.66
Common labor	do.	11.20–	15.20	$0.78	1.06
Machinists	do.	16.00	26.00	1.12	1.82
Foremen	per month	700.00–	1,000.00	49.00–70.00	
Office girls	do.	300.00–	350.00	21.00–24.50	
Bookkeepers	do.	400.00–	600.00	28.00–42.00	
Foremen of plating department			800.00		56.00

GERMANY.

Rates per day (8 hours) in rolling mills, Dresden district, December, 1919.

Rolling mill workers	$0.40
Furnace workers	.40
Machinists and blacksmiths	.38
Women workers	.14

Average rates per day (8 hours) in rolling mills in the districts of Breslau and Cologne.¶

	July, 1914	December, 1919 (8 hours)
Boys	$0.77	$0.29
Unskilled	1.32	.52
Semiskilled	1.54	.60
Skilled	2.09	.65

¶Official German report (Jahresberichte der Gewerbe Aufssichtsbeamten und Bergbehorden.)

NEWS OF THE PLANTS

The American Steel Rolling Company, 1203 North Charles Street, Baltimore, Md., is considering plans for the erection of a new plant at Eighth and Monument streets, to be devoted to the manufacture of iron and steel rods, concrete reinforcing bars, and kindred products. It is proposed to develop a capacity of about 15,000 tons of material per annum. The works will include a small open-hearth furnace. The plant will utilize scrap metal. Reuben S. Baldwin is general manager. W. Y. Schall is superintendent in charge of operations.

The Columbus Forge & Iron Co., West First avenue, Columbus, Ohio, manufacturers of anvils, forgings, and other iron products, has plans under way for the construction of two additions to its plant. The buildings will be one-story, on site at the foot of West First avenue, 110 x 125 feet, and 70 x 200 feet, respectively, estimated to cost about $85,000. Braun, Fleming, Knollman & Prior, 233 South High street, Columbus, are architects.

The Steel Fabricating Corporation, Harvey, Ill., manufacturer of steel buildings, has completed the erection of a new plant at Michigan City, Ind., and the present works will be removed to this location. The new plant aggregates about 175,000 square feet of additional floor space with approximately triple output over the former plant. Headquarters will be established at the new location.

The Kansas City Wire & Iron Works, Kansas City, Mo., has plans under way for the rebuilding of the portion of its plant. recently destroyed by fire, with loss estimated at $80,000, including machinery and equipment.

George Baker & Sons, 103 Belmont street, Brockton, Mass., manufacturers of wire nails, rivets, studs, etc., will occupy a new plant now being erected on North Monticello street by the Baker Realty Company and affiliated organization The foundation work for the new factory has been completed and erection of superstructure will be inaugurated at once. It will be one and two stories, 93 x 225 feet, and is estimated to cost about $75,000. George Howard & Sons, Inc., 633 Warren avenue, Brockton, have the building contract. George L. Falk, 153 Main street, Brockton, is architect.

The Dominion Steel Corporation, Sidney, N. S., is arranging for the immediate resumption of operations at its local plant on a full-time basis. The company recently placed a wage decrease of 20 per cent into effect and has now proposed an additional 10 per cent reduction to the men. The plant recently has been working on a basis of from one to three days per week.

The Seaboard Steel & Iron Corporation, Baltimore, Md., recently organized under Maryland laws with a capital of $200,000 to manufacture iron and steel products, has acquired property at Paca and West streets, as a site for its proposed new local plant. Plans will be placed under way at once, and details are being arranged. William F. Holl and Frederick W. Lauterbach, Gaither building, Baltimore, represent the company.

The Guaranty Iron & Steel Company, 2851 West Lake street, Chicago, Ill., have taken bids for the construction of an addition to its plant for increased production. The extension will be one-story, 100 x 200 feet, and is estimated to cost about $65,000. It will be located on West Lake street. J. A. Taggart, 19 South La Salle street, Chicago, is architect. R. J. Ross is president.

The Inland Steel Company, Chicago, Ill., has acquired a tract of land aggregating close to 600 acres in Porter County, Ind., adjoining a recent acquisition of about 250 acres in this district. The property is in the vicinity of the works of the Indiana Steel Company, Gary, Ind., and will be used by the new owner, it is understood, for the construction of a new plant. No immediate plans have been arranged for construction.

The American Steel & Wire Co., 94 Grove street, Worcester, Mass., has completed foundation work for the proposed addition to its South Works, and erection of superstructure, brick, steel and reinforced concrete, will be handled by day labor. The structure will be three-story, 114 x 120 feet, and is estimated to cost about $150,000. C. E. Goodrick, company address, is engineer.

The Oliver Iron & Steel Co., Pittsburgh, Pa., will soon commence the construction of a new four-story plant at Muriel and South Twelfth streets. Plans for the structure recently have been filed. It is estimated to cost about $100,000, including certain equipment.

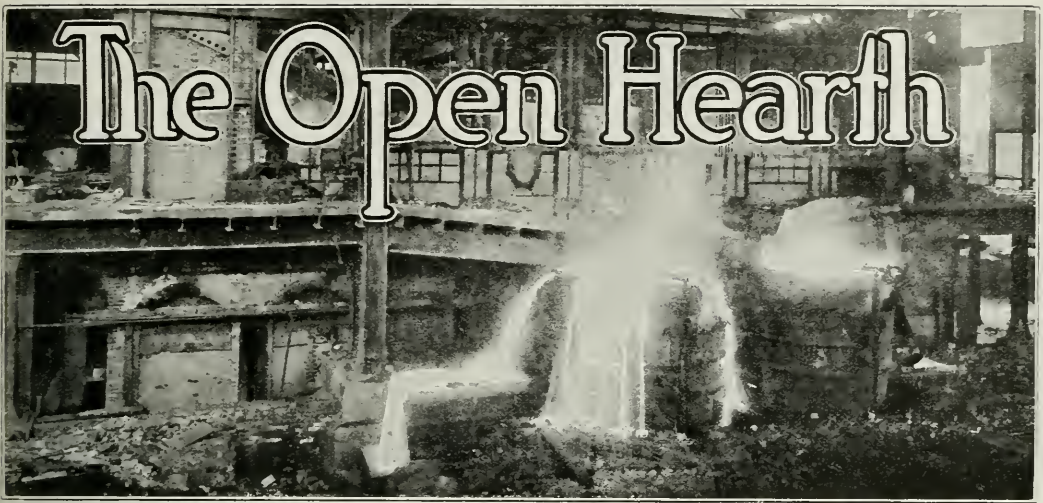
The Richard DeCou Company, Twelfth and Noble streets, Philadelphia, Pa., manufacturer of iron and steel shapes and affiliated products, has plans under way for the establishment of a new scrap-cutting and material handling yard on a thirty-acre site on the Schuylkill River. Iron working and cutting shops will be erected, and material loading and unloading equipment installed. The storage shops will be provided with material-handling equipment. It is planned to inaugurate initial work on the new plant at an early date.

The Nagel Steel Company, Pottstown, Pa., is perfecting plans for the erection of a new steel and iron works on a 200-acre tract of land, known as the Brooke Farm, near Pottstown. The plant will include open-hearth works, rolling mill, finishing mills, etc., with a number of large modern buildings for the different departments. A bond issue will be arranged to carry out the construction and machinery installations. The company has branch plants at Seyfert, Pa., and Rahway, N. J., respectively. L. F. Nagel is president of the company; E. H. Heydt, treasurer, and R. P. Cairnes, general purchasing agent.

The American Car & Foundry Company, 165 Broadway, New York, has plans under way for the rebuilding of the portion of its plant at Huntington, W. Va., destroyed by fire, May 19, with loss estimated at about $50,000, including equipment.

A. M. Castle & Co., 715 North Morgan street, Chicago, Ill., iron and steel products, will take bids at an early date for the construction of a new one and two-story building on Blackhawk street, in the vicinity of the Chicago river.

The Open Hearth



J. M. Davis, formerly vice president of the Baltimore & Ohio, has been elected president of Manning, Maxwell & Moore, Inc., 119 West Fortieth street, New York City, to succeed the late A. J. Babcock. Mr. Davis was born on November 5, 1871, and began railway work in 1888 as a freight brakeman on the San Antonio & Arkansas Pass. From September, 1891, to 1900, he served consecutively as stenographer to the superintendent of the Gulf, Colorado & Santa Fe; chief clerk to the superintendent of the Mexican Central; clerk in the general manager's office of the Great Northern; assistant superintendent and later superintendent of the Great Northern In 1900, he went to the Erie as superintendent at Scranton, Pa., subsequently serving as superintendent of the Union Steamboat Line of the Erie, at Buffalo, N. Y., and as superintendent of the Allegheny division of the Erie. He returned to the Great Northern in 1903 as superintendent, and in 1905 was promoted to assistant general superintendent of the Central district. In 1907 he went to the Oregon Short Line as assistant general superintendent, and was subsequently made acting general superintendent and later general superintendent. In 1920 he was appointed general superintendent of the Central district of the Southern Pacific, with headquarters at San Francisco, Cal. He entered the service of the Baltimore & Ohio on January 1, 1914, as assistant general manager at Cincinnati, Ohio, of the Baltimore & Ohio Southwestern—Cincinnati, Hamilton & Dayton, and later in the same year was promoted to general manager of these lines. In July, 1916, he was appointed vice president in charge of operation and maintenance of the Baltimore & Ohio System, with headquarters at Baltimore, Md., and held that position until July 1, 1918, when, under federal control of the railroads, he was appointed manager of the New York properties of the Baltimore & Ohio, including the Staten Island lines. In September, 1919, he left the Balitmore & Ohio to become president of the Rock Hill Iron & Coal Company and associated corporations, including the East Broad Top Railroad & Coal Company, with offices at New York.

J. M. Davis.

V V

Dexter S. Kimball, manager of the American Society of Mechanical Engineers and dean of the College of Engineering, Cornell University, was nominated for president of the society at its spring meeting held in Chicago, May 23 to 26. Mr. Kimball has been active in the work of the society and a member since 1900. He is also vice president of the Federated American Engineering Societies.

V V

Bradley Stoughton's resignation as secretary of the American Institute of Mining and Metallurgical Engineers, which office he has held since 1913, has been accepted by the institute's board of directors. He will terminate his services after a successor is elected and has become familiar with the work. The directors of the institute, in accepting Dr. Stoughton's resignation, formally expressed their recognition of the benefits which his work has brought to the institute.

V V

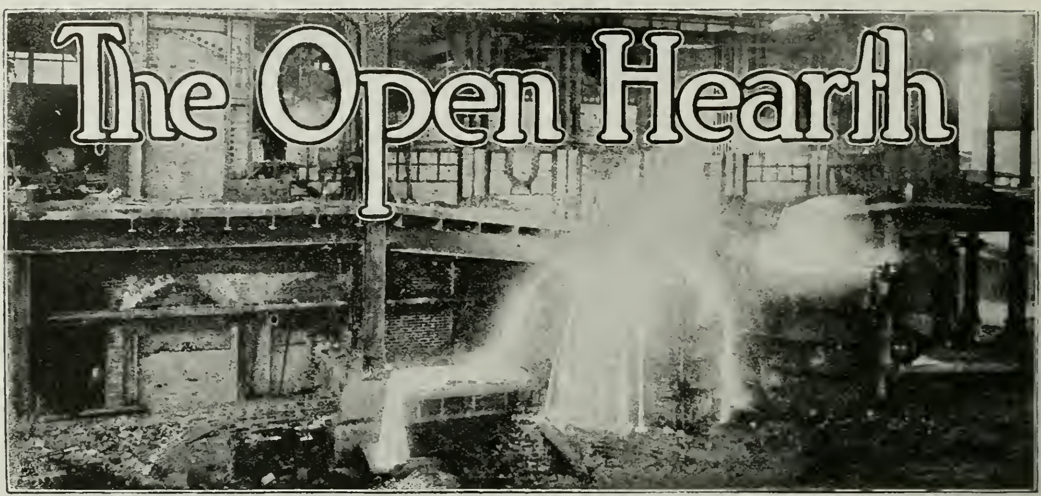
Clement F. Poppleton, 805 Duquesne way, Pittsburgh, was recently appointed consulting engineer for the Iron & Steel Products Co., 230 Fifth avenue, and the Hanlon-Gregory Galvanizing Co., both of Pittsburgh.

V V

Roy G. Owens, vice president in charge of sales of the Lakewood Engineering Co., Cleveland, has resigned. He had been prominent in the affairs of the company since the consolidation of the Milwaukee Concrete Mixer Company with it in 1917.

V V

W. L. Goodhue, who has been district manager in charge of the Dover and New Philadelphia, Ohio, plants of the American Sheet & Tin Plate Co., for the last four years, has been transferred to Farrel, Pa., where he has become manager of the company's Mercer works. William L. Davis, superintendent of the New Philadelphia plant, and William



The Open Hearth

Weichsel, superintendent of the Dover plant, have become managers of these plants.

V V

John McKay has retired as superintendent of the McDonald mills of the Carnegie Steel Company, Youngstown, Ohio, and has gone to his dairy and stock farm near Greenville, Pa.

V V

N. W. Kistler has resigned from the safety department of the Youngstown Sheet & Tube Co., Youngstown, Ohio, to become safety inspector of the Whitaker-Glessner Steel Co., Portsmouth, Ohio. In his new capacity, Mr. Kistler will have charge of the fire, police, welfare employment, sanitation and hygiene and safety departments.

V V

William Anglin resigned recently as superintendent of the bar mills of the Pittsburgh Crucible Steel Co., Midland, Pa.

V V

George S. Vail has been elected general manager of Arthur G. McKee & Co., Cleveland, blast furnace, steel plant and power plant engineers. The position is a new one and Mr. Vail, who has been with the McKee Company a number of years, has also been made a director of the company, the board having been expanded to five members.

V V

A. P. Van Scharck, who has been manager of the American Chain Company for about a year and a half, has been appointed general sales manager of the Page Steel & Wire Co., Pittsburgh, and Monessen, Pa., and affiliated interests. Mr. Van Scharck succeeds E. C. Sattley, who now is president of the Iron & Steel Products Co. W. T. Pyle, who has been connected with the Page Company for a number of years, has been appointed assistant to Mr. Van Scharck.

V V

George C. Thayer, former general manager of the Harriman plant of the Merchant Shipbuilding Corporation, Bristol, Pa., has been appointed assistant to the vice president with office at Chester, Pa. L. D. Keller has been appointed executive assistant to the vice president.

V V

J. E. Thropp, Jr., who has been blast furnace superintendent at the Columbus, Ohio, plant of the American Rolling Mill Company, Middletown, Ohio, for the past three and a half years, has resigned.

V V

L. A. Lambing was recently appointed superintendent of the open-hearth department of the Pittsburgh Crucible Steel Company, Midland, Pa. Mr. Lambing was formerly assistant superintendent of the open-hearth department of the Homestead plant of the Carnegie Steel Company.

V V

Ernest F. Perkins, metallurgist for the Oliver Chilled Plow Works, South Bend, Ind., has been appointed instructor in chemical engineering in the School of Engineering of Northeastern College, Boston. Jos. W. Zeller, who has been engaged in engineering work in Worcester, Mass., the past year, has been appointed assistant professor of mechanical engineering in the same school.

V V

F. C. Carts has been appointed general inspector and has been transferred from the Columbiana, Ohio, works of the Columbiana Foundry Company to the McKeesport, Pa., works.

V V

James A. Farrell, president United States Steel Corporation, has been elected member of the board of regents of Georgetown University, Washington, succeeding the late Anthony Hirst, Philadelphia.

V V

William N. West, formerly superintendent of the mills and roll shop of the Elyria Iron & Steel Co., Elyria, Ohio, has been appointed general superintendent, succeeding Walter Ferrier, who has severed his connection with the company.

V V

J. C. C. Holding, appointed recently as manager of the structural division of the Midvale Steel & Ordnance Co. and the Cambria Steel Company, with headquarters in Philadelphia, is a graduate in civil engineering of the Rose Polytechnic Institute, Terre Haute, Ind. Immediately upon graduation he became connected with the civil engineering department of the Johnson Co., now the Lorain works of the National Tube Company. He later spent several years in the structural drafting rooms of the Shiffler Bridge Works and the Keystone Bridge Works, Pittsburgh.

Some Pointers on By-Product Coke Oven Operations

A RECORD IN SHUTTING DOWN BY-PRODUCT COKE OVENS.

By J. M. Hastings, Jr.

In these days of business depression, many industrial plants are closing down to await a better demand for their products. Among these are many blast furnaces and steel plants, but the impression seems to have gained considerable credence that a by-product coke oven plant cannot be allowed to become cold, without serious injury and more or less complete rebuilding before it can be started again. Some owners are even going to heavy expense to keep their oven plants hot, or are selling coke at a serious loss to avoid a shutdown.

A report recently received from a plant of by-product ovens near Wheeling, W. Va., may be of interest to by-product oven owners, as it shows that a correctly designed plant may be shut down completely without serious injury.

In 1898, a plant of 60 Semet-Solvay ovens was built for the Riverside Iron Works, now owned by the National Tube Company, at Benwood, W. Va., just outside of Wheeling. Two years later, 60 more ovens were added. The plant was built on the flat land along the Ohio River, and although the records of high water were carefully studied for a long period back, the progressive denudation of the forests made these records of little value, and three years after the first ovens were started, the plant was put out of operation by high water. During the twenty years from April 24, 1901, when this first shutdown occurred, to March 16, 1921, the date of the most recent shutdown, the Benwood coke oven plant has been closed down and started up again twenty distinct times.

Seven times in that period the Ohio has flooded the district and effectively put the ovens out of commission. Most of these interruptions were for relatively short periods, although in each case the plant was kept in operation until water entered the waste heat flues. In March, 1907, however, flood water was high enough to enter the sole flues and reach the oven floors proper, causing an eighteen-day shutdown, and in April, 1913, the worst flood in the history of the river brought the water into the lower heating flues fifteen inches above the floor of the ovens. On this latter occasion a shutdown of twenty-five days resulted, largely because natural gas for starting up again was not available for some time after the flood subsided.

In addition to interruptions caused by floods, the plant has been down four times on account of coal shortage, twice for repairs to the hydraulic mains and seven times on account of business conditions. Duration of shutdown from this last cause has ranged from one month in 1914 to a year and seven months in 1907 to 1909.

During its entire twenty-two and a half years' existence, the Benwood plant has been shut down 1,958 days, or a total of five and one-third years up to March 16 of this year, since which date it has again been cold. Several other Semet-Solvay plants have been shut down for varying periods, but none have approached this record and probably none ever will, due to the peculiar circumstances at Benwood.

Notwithstanding this rather remarkable record of shutdowns, the present condition of the plant shows that it has suffered no serious damage. Of course these extraordinary and repeated stresses on such a large amount of brickwork cannot be encountered without some injury and expense for repairs. But the construction of this type of oven, with the well-known strong division wall between the ovens, was so substantial that any injury occasioned by these vicissitudes has been of a minor nature, as is shown by the following records.

Of all the ovens built in the United States, No. 30 oven in Block No. 1 at Benwood holds the record for low repair costs. This oven has gone through all the vicissitudes mentioned, has been in operation seventeen years and out of run twenty times for a total of over five years, and to date has required no replacements whatever in its lining or brickwork. No. 60 oven in Block No. 2 is a close second, having required less than $20.00 expense for brickwork repairs. It should be further noted that the two ovens mentioned at Benwood are both end ovens, which is the point where injury to the structure of the blocks often first appears. The repair records of these two ovens are of course exceptional, but the record of the entire plant has been remarkable, despite the numerous interruptions.

In addition to these repair records on the ovens, the yields obtained at the Benwood plant have been very satisfactory and compare favorably with those from the best modern plants. For the five-year period from January 1, 1915, to January 1, 1920, during which time the plant enjoyed fairly continuous operation, the average results were as follows:

Analysis of Coal Charged

Volatile	29.9%
Fixed C.	62.2%
Ash	7.9%

Yields Obtained

Total coke	78.2%
Sulphate of ammonia	24.5 lbs. per ton
Light oil	3.11 gals. per ton
Tar	10.0 gals. per ton

These records show conclusively that that plant has not suffered by reason of its many shutdowns and the same should be true for any correctly designed oven plant. Of course it is necessary to exercise care and to take certain precautions when closing down a coke oven plant for an indefinite period. The process is, in general, just the reverse of that employed in starting up a block. The heats should be lowered gradually by a gradual reduction in the supply of fuel gas, so that the contraction of the block will take place slowly and regularly. As this contraction progresses, the tie rods must be readjusted and a close watch maintained to guard against cracks developing.

If the coke is left in the ovens, as is sometimes done when a long shutdown is not anticipated, the greatest care must be used in sealing the ovens as nearly airtight as possible. The door frames must be kept tight against the brickwork, uptake pipes maintained in proper position and charging hole covers sealed tight. With an experienced operator in charge, experience has shown that there is no reason why a block of ovens of correct design cannot be shut down for a longer or shorter period, without extraordinary labor or heavy repair expense on starting up.

TRADE NOTES

Charles Copeland, assistant treasurer, has been elected a member of the Board of Directors and secretary of the E. I. du Pont de Nemours & Co., to fill the vacancies caused by the death of Alexis I. du Pont.

The Chateaugay Ore & Iron Co. has engaged Freyn, Brassert & Co., engineers, Chicago, for the work of remodeling its blast furnace plant at Standish, N. Y., and for the construction of a sintering plant at its mines at Lyon Mountain, N. Y. The blast furnace stack is to be enlarged in capacity and the plant modernized by the addition of mechanical handling equipment. The sintering plant at Lyon Mountain mines will supplement the ore concentrating plant and will produce a low phosphorous copper-free sinter for shipment to the blast furnace at Standish.

In order to handle more satisfactorily its growing detinning business in the West, the Metal & Thermit Corporation has constructed and will shortly place in operation in South San Francisco, Cal., a large new plant for the production of detinned billets, in addition to the detinning plants already operated by this company for several years at Chrome, N. J., and East Chicago, Ind.

Mr. J. B. Johnston, vice president and general manager of The Standard Scale & Supply Co., Pittsburgh, Pa., has resigned.

Willard C. Brinton, president of the Terminal Engineering Company, Inc., makes the following announcements: J. F. McGonigal, mechanical engineer, formerly of the Foamite Company, and J. H. Potter, mechanical engineer, a graduate of New York University, have joined the organization. M. E. Lyle, for many years with the Columbia Graphaphone Company, has been elected a vice president and is directly responsible for new business. M. E. Peck has been elected secretary and assistant treasurer.

The M. J. Dougherty Company, piping fabricators and contractors of Philadelphia, announce a change of address of their Atlanta representative's office address to Candler Annex. This office is in charge of Messrs. McKee and Wright, who have had an extensive experience in the engineering field and are widely known in the South, having been actively engaged in the power field for nearly a score of years.

The International Nickel Company, 67 Wall street, of which W. L. Wotherspoon is chief engineer and Frank I. Ellis, 2126 Farmers Bank Building, Pittsburgh, Pa., consulting engineer, have placed the contract for 2-pair, 2-sheet and 6 annealing furnaces with the Surface Combustion Company, 366 Gerard avenue, Bronx, New York City, through the latter's Pittsburgh office, 927 Union Arcade. These furnaces will be fired by the Surface-Combustion process, using natural gas, and will be installed in the International Nickel Company's new plant at Huntington, W. Va.

TRADE PUBLICATIONS

Dayton-Dowd Company, Quincy, Ill., has issued Bulletin No. 244, covering advances made in design and application of their centrifugal pumps. It contains photographs and tests covering the use of these pumps.

Hyatt Roller Bearing Company has issued a complete truck report, the nature of which shows the advantages of using roller bearings in industrial tractors and trucks.

Atlas Valve Company, Newark, N. J., has issued Bulletin No. 5, covering the Victor damper regulator No. 3, high pressure. This regulator is designed for boiler pressures up to 250 pounds. This bulletin will be sent out upon request.

Geo. J. Hagan Company has issued Bulletin L. F. 103, entitled "Liquid Fuel Burners for the Generation of Steam." This booklet is very complete in every detail and shows a number of cross-sections of various burner settings.

Steam Tables for Condenser Work.

The Wheeler Condenser & Engineering Co., Carteret, N. J., announces the publication of the 1921 edition of its popular "Steam Tables for Condenser Work." This is the sixth edition of a work which for many years has been widely used by engineers dealing with the condensation or evaporation of steam. The tables are in a very handy book form, pocket size. The properties of saturated steam are tabulated from 29.8 inches vacuum to atmospheric pressure in increments of tenths of an inch referred to a 30-inch barometer. The values were especially calculated for this book by Professor Marks. As it is customary in vacuum work to read vacuum in inches of mercury, this is superior to the old method of giving absolute pressures in pounds per square inch. Above atmospheric pressure the increments are in pounds gage. The book explains how measurements are made by means of the mercury column and barometer, and gives constants and tables for making corrections. Corrections for the thermal expansion of mercury, for the relative expansion of mercury and brass scale, and other corrections are included.

"C-H Elevator Controllers" is the title of a 40-page book just published by The Cutler-Hammer Manufacturing Company. In addition to a description of the various C-H elevator controllers and accessories, the book contains a discussion of the types of motors best suited to elevator work and an outline of the usual method of selecting motors of the right horsepower and starting torque to insure satisfactory performance. Tables giving motor, fuse and wire ratings are also included. An index makes it easy to turn to any particular section of the book.

The American Steel & Wire Co., New York, has issued a 50-page booklet which contains a history of slack cooperage as well as a catalog of twisted splice and electric welded wire hoops manufactured by the company. The booklet details the various products of the American Steel & Wire Co. for the cooperage industry, together with the method of using these products.

Air and steam motors, pneumatic hoists, contractors' hoists, crane hoists, hoisting engines, swinging engines, motor crabs, electric hoists, steam steering gears, spud hoists, capstans, windlasses, fish net lifters, etc., are described and illustrated in a 72-page illustrated booklet recently published by the Dake Engine Company, Grand Haven, Mich. This booklet describes the various products of the company in detail, giving specifications, etc.

A large 40-page illustrated booklet has been published by the Cutler-Hammer Manufacturing Company, Milwaukee, in which elevator controllers are described and illustrated. According to the booklet the salient features of these controllers are renewable carbon to copper power contacts; a constant time element type of acceleration; quiet, sure-operating magnetic contactors; simple construction with few auxiliary interlocking contacts The controllers are described in detail.

The Elecric Hoist Manufacturers' Association, New York, has published a 12-page illustrated bulletin in which approved applications of electric hoists are given. The list to which such hoists have been put to use successfully includes automobile manufacturing plants, airplane factories, bolt, nut and screw plants, brass and copper mills, brick yards, by-product plants, car manufacturing plants, repair shops, chemical plants, electric light and power plants, enameling plants, forging plants, foundries, and numerous others.

The Sanitation Corporation, New York, has published an interesting booklet entitled "The Sanitation of Cities," in which the sewage disposal problems of large municipalities, and small ones as well, are described. The booklet is printed on heavy coated stock, is profusely illustrated with cuts of various cities of the world, including New York, Berlin, Paris and southern and western American cities, showing how the various cities dispose of their sewage. The booklet contains 120 pages. It can scarcely be called a catalog as it is more of a treatise on the question of sanitation in the city.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., AUGUST, 1921 No. 8

Rotary Kiln Lime Burning Plant

New Plant Recently Built at the Granite City Steel Works of the National Enameling and Stamping Company, Granite City, Illinois

DURING recent years the delivery of material according to manufacturing needs has been a problem, particularly where such material could not be stored for any great length of time. This transportation difficulty was one of the reasons for the installation of a lime burning plant at the steel works where the raw material or limestone could be stored in sufficient quantity and burned to meet requirements.

This plant consists of building and equipment for raw material, two rotary kilns eight feet diameter by 110 feet in length, which are not housed, building at finishing end which houses the electrical control equipment, pulverizers, storage for coal at pulverizers and storage for finished lime. Reinforced concrete construction was used throughout for the main buildings and storage bins.

Since labor costs are a very serious factor in present day operation, the plant has been designed to operate with a minimum force, this being accomplished by the mechanical handling of material and by a convenient arrangement of the equipment. All raw material is received on one track and passed into the "raw end" of the plant. Lime stone is delivered to the plant by rail in 1½" to ⅝" size. The fines below ⅝-inch are screened out at the quarry. If received in dump cars, the stone may be dumped directly to the storage bins, which are below the track level or if received in solid bottom cars, a crane is used for unloading either directly to the overhead bins which supply stone to the kilns or to the storage bins below the track level from which the stone is handled to the overhead bins by the crane. Coal is also received at this end of the plant and unloaded in the same manner into storage bins partitioned off for this particular purpose.

The "raw end" of the plant consists of four storage bins below the track level, two 90 ton overhead bins for raw stone, one coal hopper with single roll crusher and

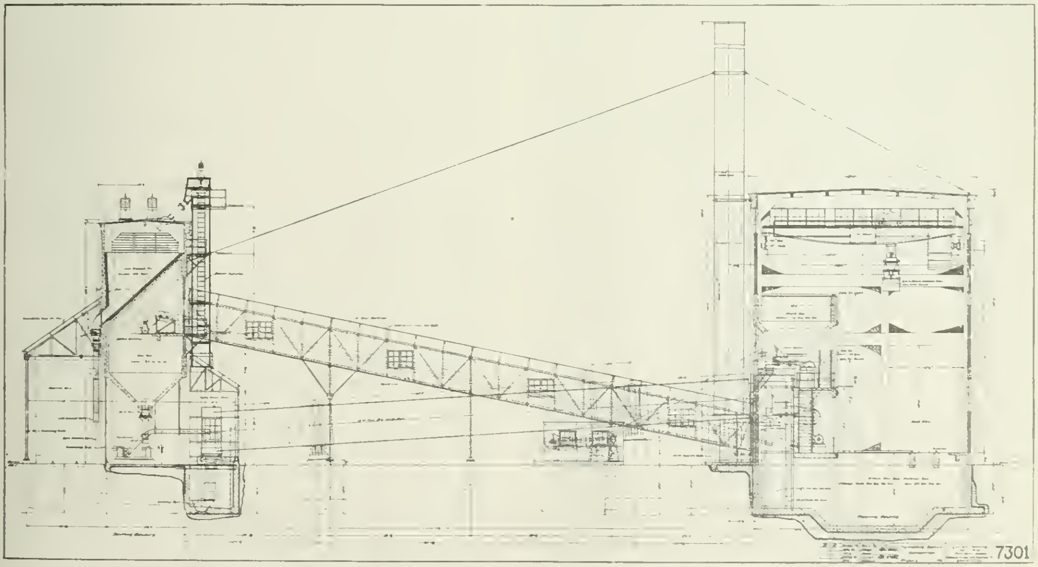


Fig. 1—General layout of new rotary kiln lime burning plant.

apron feeder, plate feeders for regulating supply of lime stone to kilns, crane for handling stone and coal and the necessary building to house this equipment.

There is approximately 1,500 tons total capacity in the storage bins below the track level of which 800 tons is for stone exclusively, 350 tons for coal and 350 tons for either stone or coal as conditions may require. Bituminous coal having a very low sulphur content is used. After being received at the "raw end" of the plant and passing through the crusher, this coal is conveyed to the "finished end" of the plant by means of an inclined belt conveyor and a scraper conveyor which distributes the coal to two overhead storage bunkers. At this point coal is fed directly to pulverizers which pulverize and deliver the coal to the kilns in one operation supplying at the same time the proper amount of air for combustion.

The coal conveying and crushing equipment is motor driven and automatic compensators are used in order to secure the advantage of interlocking control. This control is arranged in such a way that the conveying equipment cannot be started or operated except in the proper sequence which obviates the possibility of piling up coal at some intermediate point due to failure of any one unit in the whole conveying equipment. The interlock is so arranged that the scraper which distributes crushed coal to the storage bins over the pulverizer is the first unit to be placed in operation, this being followed by the belt conveyor; the crusher being the last unit to go into operation. Should the power supply to either the scraper or the belt conveyor be interrupted, the crusher will be automatically closed down.

By the use of the pulverizer selected for this installation, the cost of coal plant is reduced to a comparatively low figure as compared to the conventional coal pulverizing and preparation plant consisting of dryers and grinding equipment. Since at a later date this plant will in all probability be changed over for operation on gas as fuel, it was advisable to hold the investment in coal pulverizing plant as low as possible. Very satisfactory results have been secured however with this equipment, the only difficulty which has been experienced being when an unusual amount of moisture was present in the coal, which increases the power consumption of the pulverizers very materially.

While two kilns are installed, one is sufficient to provide for normal operation of the present open hearth furnaces, since one kiln has a capacity of 60 to 65 tons of finished lime per 24 hours. With the second kiln as a stand-by and the large storage capacity, ample assurance is provided for a continuous supply of lime.

At the "finishing end" of the plant, storage has been provided for 130 tons of coal and 185 tons burnt lime, this storage all being arranged for gravity discharge to the pulverizers in the one case and to open hearth charging boxes or to standard car in the other case. Both standard gauge and industrial tracks are served by the lime storage, the finished lime being loaded directly into charging boxes on the industrial track and delivered to open hearth furnaces. In normal operation this permits of charging lime before it has completely cooled, thus giving the open hearth furnace some little advantage of the heat required for burning the lime.

Motors on kilns, pulverizers and conveying equipment are 440 volt, three phase, 60 cycle induction motors and power is supplied for these motors from the mixed pressure turbine plant, which was also designed and erected by the Engineering Service Corporation. Kiln motors and pulverizer motors are variable speed slip-ring type and are controlled from firing floor as are all motors for conveying and elevating equipment.

The crane is equipped with direct current motors and current is supplied by motor generators in the turbine plant. Direct current is also supplied to magnet for collecting tramp iron which may be present in the coal. One of the outstanding features of the plant is the liberal dust separating chamber between the rotary kiln and the stack. Very efficient dust separation is obtained, practically no dust escaping from the stack. This is an important feature and one which is being given a great deal more consideration at the present time than has been the case in former years, not only from the standpoint of cleanliness, but for the recovery of valuable by-products. This dust chamber is arranged for convenient cleaning and the dust may be handled by the crane bucket directly into a standard car. The kilns are served by individual stacks 6 feet inside diameter by 90 feet in height. Provision has been made for extending the plant at some future time, reinforcing steel and connections being left at the proper points for this purpose. After changes are made for operation on gas, which is now available, commercial lime may be produced in addition to supplying the requirements of the open hearth furnaces.

This plant was designed by the Engineering Service Corporation of St. Louis and the entire construction was also under their supervision.

CHEMICAL EXPOSITION SEPTEMBER 12-17

In a most impressive array, the remarkable and spectacular achievements of American chemistry, brought so forcibly to the attention of all nations during the World War, again will be unrolled in a panorama of practical, educational and helpful exhibits at the Seventh National Exposition of Chemical Industries at the Eighth Coast Artillery Armory, New York City, during the week of September 12.

Acording to the directors of the exposition, America has taken the lead in the world's chemical industry since the war, and not only the experts, students, manufacturers and general public of the States, but foreign nations, particularly the ones that formerly did a big business with Germany are greatly interested in the progress that America has made.

The growth of the Chemical Exposition during the last seven years has ben a barometer of the trend of public thought and interest in America's scientific achievements. Manufacturers, engineers, scientific men and students are drawn toward these remarkable displays from all corners of the country. It has, therefore, become necessary to stage the 400 exhibits of this year's event in an exposition building of immense proportions, covering an area of five city blocks. As much of the program is carried out in speeches, lectures, and papers of value to the investigator along these lines, a special auditorium arranged according to the plan of a theater, and having a seating capacity equal to many such houses, will meet the needs of a quiet and comfortable lecture hall. It will offer an ideal place for the many symposiums that will be held during the week.

Discussion on Open Hearth Practice

Some Facts and Data Pertaining to Combustion Efficiency in an Open Hearth Furnace — Open Hearths of Today Have Not Shown Their True Ability.

By HENRY WILLIAM SELDON, B.S., Met.Eng.,
See-Seldon and Associates, Engineers.

STARTING with the fundamental parts of an open hearth furnace we elaborate or modify our furnace construction in order to make steel more quickly, or to reduce the heat losses, or to increase the furnace life. In other words we change the construction of our furnace to attain some specified object more efficiently. The first and most essential component upon which we find the successful operation of an open hearth furnace depends is primarily one of securing efficient combustion.

In order to obtain more efficient combustion after we adopt a reverboratory type of furnace, is to use checker brick to absorb and recover some of the waste heat. We do this because knowledge and experience has proven that the speed and temperature of combustion is increased by pre-heating of the air (and producer gas).

Likewise we know or should have determined by past experience the best size and location of gas and air ports necessary to supply the requisite amount of gas and air at a velocity best suited to the furnace requirements. We provide a stack damper to regulate the draft on the furnace in order that we obtain all the heat possible from our burnt gases and also to provide additional draft as the age of the furnace increases and the flue passages become smaller. Should we find the temperature of our gas or air chambers do not correspond, or the draft is not evenly distributed we have provided individual flue dampers which can be regulated to correct such a condition.

It is absolutely essential the various valves and seals shall work properly and be free from leaks, otherwise our balanced machine will be hopelessly out of running order.

It becomes evident when we get down to elementary reasons and principles that checkers are installed to pick up waste heat from the burnt gases. The number and method of construction can be anything which will supply sufficient heat, (obtained from the waste gases), to the incoming gases without interfering with the passage of the gases in either direction. Likewise the efficiency of our furnace increases as the temperature of our incoming gas and air is increased. Provided our furnace has sufficient draft and our incoming gas and air is being sufficiently pre-heated we can forget about our checkers.

After we have found the best type and method of construction and have built our furnace accordingly still we find a variation in the working qualities.

If we would maintain uniform results it is desirable to provide all manner of means for adjusting the various portions of equipment in order to correct faulty conditions. In this case an intelligent and experienced operator will use the means of adjustment which are provided and the result is the faulty working will be overcome.

The point aimed at in this discussion is to try to show that the difference between a furnace working satisfactorily and one working otherwise is one of efficiency and in the majority of the open hearths it is primarily one of efficiency of combustion.

The operating furnace is continually undergoing changes by virtue of the unavoidable wearing down at some points and the building up of others. The result in some cases is we find the furnace works better as it gets older; in many others we find it is getting worse. In the latter case experience will locate the cause but its correction will depend upon the means of adjustment available and the cause of the trouble.

In many open hearth furnaces the amount of fuel used is excessive and could be reduced if the first helpers could regulate their fuel and air intelligently and to suit the furnace requirements.

If we are to increase our tonnage in such a shop it will absolutely be necessary to have the furnace work sharply and this can be done *continuously* by constant regulation of the fuel and air mixture.

Due to the construction of some furnaces it is possible to operate with practically no air being taken through the air checkers. This is possible because air is drawn in through the various openings of the furnace and is the reason why the first helpers have formed the opinion it is unnecessary to regulate the air. As further evidence that the first helpers and melters need instruction on burning their fuel we cite the fact that during one entire week the hydraulic line operating the air inlet valves was frozen on several furnaces, and the furnace operators never knew their air valves did not work.

By the utilization of the pre-heated air obtained from the air checkers and by making a more suitable gas it is possible in many cases to speed up a furnace. This is entirely dependent that the first helper regulate with intelligence the gas and air mixture. A very striking illustration of the valve of regulating gas and air is shown by the ordinary Welsbach gas mantle used for lighting purposes with natural gas. The effect on the lighting qualities is instantly shown by increasing either the air or gas supply independently. Since the lighting qualities of the gas mantle depend upon the combustion efficiency of the gas and air mixture we see at once that it is just as bad to have too much gas in our mixture as it is to have too much air.

We are satisfied that this condition of too much fuel for the supply of air is common in open hearths. For example the practice is to set the air valve by chance to suit an average or supposed average of gas and seldom change the air supply. The result being the furnace works slower, does not require such constant watching and in general puts all blame for any variation in the working of the furnace on the gas house. It is asking the gas maker to send over just the right amount and quality of gas to suit the amount of air on the furnace when the gas maker's conditions are quite variable and he usually has no means of telling the requirement of the furnace.

Better combustion will increase the tonnage of the furnace, increase the life of the furnace and eliminate considerable of the present checker troubles by reducing the volume of the gases to be handled.

Use the correct amount of air, use pre-heated air, use the stack damper to utilize the heat from the various volumes of gas burned and the furnace will produce increased tonnage with a lower fuel consumption.

The progressive manager is well aware of the inefficiency of an open hearth furnace and basing his opinion on past performances is inclined to reason that radical changes must be made in design before they will be overcome. The lingering doubt in his mind is caused by the recollection of some particularly fine furnace which for a short time had worked so well for him. Also the sad fact remains that of two furnaces built after the same design one will make heats in eight (8) to twelve (12) hours while the other will take from fourteen (14) to twenty-four (24)) hours. Every superintendent has his reason but only one can be correct.

Without fear of disapproval and in light of our experience we assert that the open hearth furnace as built to-day has not been forced to show its true ability and that the present tonnage records are poor examples of what can be accomplished.

Lubrication of Gears and Pinions

One of the Important Problems for the Steel Mill Master Mechanic Is the Proper Lubrication of Steel Mill Drives — Some Pointers On How to Properly Lubricate Certain Parts of the Drive.

By W. F. OSBORNE,
Engineer, The Texas Company.

EVER since the beginning of the iron and steel industry gears and pinions have been used in large numbers for transmitting power. Steel rolling mills in particular necessarily use pinions for driving the rolls at the proper speeds. The drive is positive, convenient, occupies small space and is relatively inexpensive as compared with the cost of other drives.

The principal objection to the gear drive has been the high frictional losses which amount to a very large proportion of the total frictional losses of the entire mill, and increase much more rapidly with increased loads than do the losses within the bearings. Another serious objection has been the rapid wear and the cost of frequent renewals.

Until recently, within the past ten years, the practice has been to use rough cast pinions and gears, except for the smaller gears such as those of electric cranes which were machine cut. These gears were protected only by such guards and covers as might be necessary to keep the operators from being hurt. Under such conditions the gears were subjected to the most severe service, covered with steel dust and scale flying from the rolls, exposed to heat from the hot metal and frequently soaked with water used for cooling roll necks and pinion bearings.

On account of the construction of these old mills, it is quite impossible to maintain anything like good alignment of gears and pinions so that the pinion necks must be free to move slightly with the irregularities of rotation.

Is it any wonder, with such conditions, that frictional losses are so high?

There are still a very large number of these old mills in operation and a surprisingly high percentage of the new mills have been built without any improvement having been made in gear conditions.

When a new, rough cast gear or pinion is put into service, it should be run dry for a short time to break off the rust and to wear off the worst of the rough spots and moulding sand. If the pinion becomes too hot, a stream of cooling water can be used until the gear teeth show something like a smooth surface. Then the gear lubricant should be applied direct to the teeth until they are completely coated. Subsequent applications will depend upon local conditions.

If the gears or pinions are enclosed in a tight casing, a sufficient quantity of the lubricant may be introduced so that the lowest teeth will just dip into the lubricant when running. This provides what is called "bath lubrication." When the gear casing is not tight enough to hold a bath of the lubricant, lubrication is secured by direct applications to the gear teeth at frequent intervals, so as to maintain a lubricating film on the teeth. The frequency of applications and the amount required vary with the construction of the mill, the condition of the teeth, the operating service and the kind of lubricant. Some mills have to lubricate gears without bath every eight hours, others only once in twenty-four hours. With the bath system additional lubricant is required only when leakage lowers the level of the lubricant below the lowest gear tooth, or when it becomes necessary to clean the gear case on account of an accumulation of foreign matter.

The bath method has many advantages over the direct application, as it provides continuous lubrication of ample quantity, assuming, of course, that a suitable lubricant is used which will drain back to the bottom of the gear case when splashed against the sides of the gear cases by the gears. The tight casing keeps the greater part of the steel dust and scale off the teeth, increasing the life of the gear lubricant and reducing wear.

Care must be exercised in adding lubricant to the gear case, so that the level of the bath is not too high. Too much lubricant will increase the frictional resistance of the gears passing through the bath, thereby raising the temperature unnecessarily, and reducing the viscosity of the lubricant. It has frequently occurred that the viscosity has been lowered through increased temperatures to the point where the lubricant was no longer heavy enough to prevent wear of the teeth. Only enough lubricant should be supplied to allow the teeth to barely dip when running. Too much lubricant also makes starting in cold weather difficult, blowing fuses on electric motors, springing shafts and even breaking bearing caps and bolts.

The lubrication of gears and pinions has far reaching effects beyond the frictional losses of the gears, their wear and the cost of replacement. For instance, in a direct coupled mill having several stands driven off one set of pinions, insufficient lubrication of the pinions will cause a hesitating, jerky, rotation of the rolls, accentuated at the end set, resulting in a non-uniform product. As the end stand is usually the finishing set of rolls, it is sometimes driven through a separate set of pinions on this account. An improvement in the lubrication of the pinions will eliminate a great deal of the trouble in securing uniformly finished bars.

For gears on which frequent direct applications must be made, certain characteristics should be possessed by the lubricant.

1. Adhesiveness enough to stick to the gear teeth under the operating conditions of speed and temperature.
2. Enough body (high enough in viscosity) to prevent or reduce metallic contact to a minimum.
3. Sufficient fluidity to spread uniformly over the gear teeth (viscosity of a lubricant can be reduced by heating before making applications. This is the usual practice as all suitable gear lubricants are so viscous at ordinary temperatures that they will not adhere or spread properly unless heated).
4. Remain plastic and retain its lubricating properties under the lowest temperature conditions to which the gears might be exposed.
5. Impervious to hot or cold water which might be splashed onto the gears from the rolls.

The use of the bath system modifies some of these requirements slightly.

1. The lubricant should be fluid enough at all operating temperatures to drain back to the bottom of the gear case to maintain continuous lubrication.
2. It should not be so viscous as to cause excessive frictional losses or high temperatures if the bath level should be carried a little too high.
3. The viscosity should be low enough to permit sediment to settle to the bottom of the gear case, reducing the abrasion of the gear teeth.

The use of machine cut gears and pinions, of the herringbone type has greatly improved the lubricating conditions, as such gears offer a comparatively smooth working surface, reducing frictional losses and making unnecessary the extremely heavy lubricants which are required to cover up the rough spots in the cast gears. If these gears are enclosed in a gear case, providing bath lubrication, the viscosity of the lubricant can be reduced considerably, lowering frictional losses due to the excessive viscosity of the lubricant, without increasing the friction of the teeth by metallic contact.

In designing fully enclosed gear sets of this type, careful attention ought to be given to the design of the bearings to prevent the leakage of the gear lubricant into the bearings, and vice versa. A suitable lubricant for a gear set of this type is so fluid that it is splashed all around the gear case and will run down the sides onto the shafts. Unless suitable stuffing boxes are provided it will work into the bearings, increasing the friction and raising the temperature. In other installations the oil in the bearings may leak into the gear case in sufficient quantities to lower the viscosity of the gear lubricant so that it will no longer lubricate the gears.

An improvement in gear lubrication has recently been made by certain builders, in constructing reduction gears so that one lubricant can be used throughout for bearings and gears. This eliminates the stuffing boxes between gear bearings and the gear cavity, and there is no longer any necessity for keeping the lubricants separated. It also removes the troubles due to mixing of the lubricants. In order to use one oil for gears and bearings it must be fluid enough to prevent high frictional losses within the bearings and yet sufficiently viscous to withstand the high tooth pressures. In effecting a compromise, the successful gear manufacturer must understand fully the laws of lubrication and the influence of viscosity. As it cannot be expected that every mill master mechanic is going to be an expert on oil, the gear manufacturer ought to determine the correct viscosity oil to use under various operating conditions and advise the mill people what viscosity should be used.

When oil is used as the lubricant it is very desirable to furnish the gears with a pump and spray the oil onto the gear teeth just before they mesh. In this way a positive supply is insured. If the bath system is depended upon, it is highly probable that the air currents induced by the high speed and centrifugal force will throw most of the lubricant away from the teeth and only a very thin film of oil will remain to protect the teeth against wear. If a sufficient quantity of oil is flooded onto the gears, they can be lubricated with a lubricant much less viscous than the usual type of gear lubricant.

From the standpoint of reducing frictional losses, lowering temperatures, and facilitating circulation and separation of sediment, the lowest viscosity oil should be used which will satisfactorily lubricate the gears with a margin of safety to take care of abnormal conditions.

When the viscosity has been selected, the gear bearings should be designed with the proper clearances to allow its use without excessive heating. If oil is supplied to the bearings in a copious stream and clearances are large enough to permit the formation of a perfect oil film, the frictional losses will be reduced to a minimum and will vary directly as the speed, the absolute viscosity of the oil, and inversely as the clearance space between shaft and bearing, all other conditions of design and loading remaining constant. This indicates that if the temperatures are excessive with the use of a viscous oil, they may be lowered by increasing the bearing clearance. In most cases the bearing clearances can be made large enough to prevent high temperatures without at the same time permitting vibration and mis-alignment of the gears. If the speeds, particularly on reduction gear sets of a high ratio, and loading conditions are such that bearing clearances and the viscosity of the oil cannot be satisfactorily adjusted by this method, there is still an alternative.

The viscosity of every oil changes with the temperature, becoming lower as the oil is heated and higher as it is cooled. This property can be used to advantage for gear lubrication when the outfit is large enough to warrant the use of coolers, and heaters in the oiling system. When the force feed spray system is used, the hot oil from the bearings may be allowed to drain into the case. If this warm oil is too viscous for the bearings, a portion of it can be heated sufficiently to reduce its viscosity to that required by the bearing clearances. When an oil having a steep viscosity curve is used, a comparatively slight increase in the temperature will lower the viscosity considerably and although this may raise the bearing temperatures slightly in some cases it will reduce friction and wear. The remainder of the oil which has not been reduced in viscosity can then be supplied to the gears.

New Use of Recording Instruments

Installation of Bristol Recording Instruments at the Blast Furnace of Weirton Steel Company, Weirton, West Virginia, Cause Operating Improvements In Regulation of Furnace.

THIS fine blast furnace plant has a very complete equipment of automatic recording instruments, including recording pressure gauges, vacuum gauges, thermometers, pyrometers, time recorders and tachometers. These instruments are of great service in helping the superintendent and his assistants to get the best possible results. Some of the recording instrument installations are shown in the accompanying illustrations.

The cold blast as it leaves the blowing engines is the first operation to be recorded. The next point is the hot blast pressure just ahead of the bustle pipe. Any excessive discrepancies between these two records of pressure is an immediate indication of trouble.

The top gas pressure is next in order to be recorded; the pipe connection for this is made in the dust catcher. This record gives a good indication of how the stock is working down, and in some cases even gives forewarning of slips. The pressure in the gas main is again recorded on a two-pen instrument; one pen connected before the washer and the other pen after the washer. This record shows any loss in pressure while passing through the washer. In addition to these a record is made of the clean gas pressure at the stoves for the foreman, and the clean gas pressure at the boilers for the boiler operator.

The temperature of the blast and gas is recorded at several points; first at the intake to the blowing engines, because the speed of the engine is varied with the change in temperature of the atmosphere. The hot blast temperature is then recorded, and this point in the process is of such great importance that two pyrometer instruments are connected to one fire-end, one an indicator, the other a recorder. The indicator with the big, easily read scale is installed in the stove tender's shanty and enables the tender to maintain a uniform heat. The recorder is located in the foreman's office and gives him a continuous record of just what temperatures are held. The fire-end for the hot blast is located in the hot blast main just ahead of the bustle pipe. The top gas temperature is also of great importance, and is to some extent controlled by the skip operator. The indicating instrument for the top gas temperature is in the skip house where the operator can see it at all times, while the recorder is installed in the foreman's office: the fire-end is located in the dust catcher. The temperature of the clean gas is recorded as it leaves the dryer, so that accurate information as to how much heat is lost in the cleaning process is thus always available. Finally the temperature of the gases of combustion leaving each stove is recorded at the chimney valve. The recorders, one for each stove, are located in the foreman's office and gives him complete information as to how long each stove is on blast and how long on gas. These records also give an indication of the extent to which the checkerbrick is absorbing the heat.

It is very essential that there shall be no lack of water to the bosh, and to insure this a recording pressure gauge is installed on the line. The record made on this instrument shows immediately any faltering of the pumps supplying the water.

The water before and after the washer is recorded on one chart by a two-pen recording thermometer. This supplies valuable information as to the performance of the washer, and the double record of the one chart makes comparison easy.

It is just as important that a blast furnace boiler room operate efficiently, as it is for that of a large generating station, therefore, in the boiler room are a recording steam pressure gauge, for the operator

Fig. 1

Recording instruments in blowers' office, not all of the instruments are shown in the cut.. The top row includes recording pyrometers for hot blast and top gas. Below on the second row are the pressure gauges for hot blast pressure and top gas pressure, operation of skip, big and little bells and rotary top, Bosh water pressure, and pressure before washer and after dryer. Continuing in same row, but not shown, are recording pressure gauges for clean gas pressure at stoves, recording thermometers for clean gas temperature leaving dryer, and water temperature before and after washer. The racks show convenient method for filing charts after removing from instrument.

Fig. 2

This shows fire-end installation of pyrometer for measuring temperature of gases of combustion leaving one of the stoves.

Fig. 3

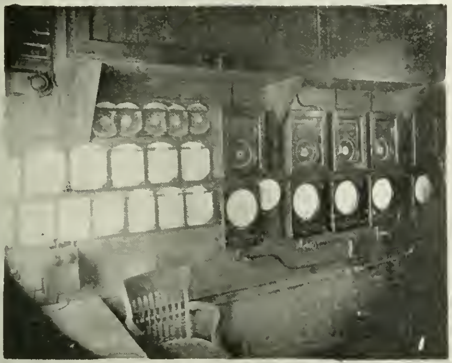
Partial view of power house showing in the foreground two turbo-generators, and on the wall between them are to be seen the condenser vacuum recorder, incoming water pressure recorder, and the three-pen thermometer for the condenser of the right-hand turbine. At the right of the picture is shown part of one of the two horizontal blowing engines. On the wall are the various instruments. The pressure gauge on the pillar is recording cold blast pressure. Next comes the Mesta gaugeboard with a recording tachometer in the center.. Beyond that are the vacuum, water pressure, and three-pen temperature recorders for the blowing engine condenser. There is also a recording pressure gauge for steam entering the power house. In addition is the recording thermometer for atmospheric temperatures, and tachometer for second blowing engine. There is only one set of condenser instruments for the two blowing engines, since both engines use the same condenser. This is possible because only one engine runs at a time.

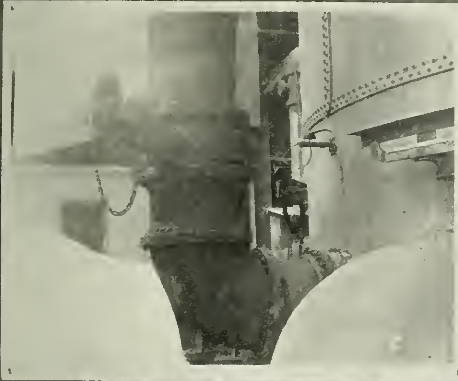
Figs. 4 and 6.

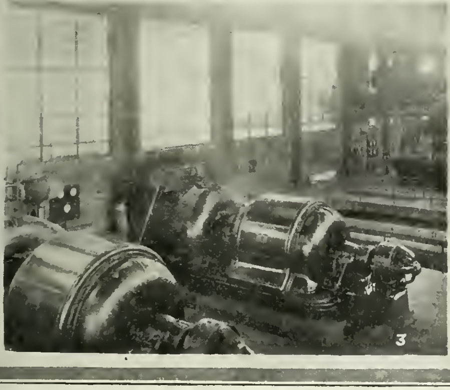
Closeup views of instrument boards in the power house.

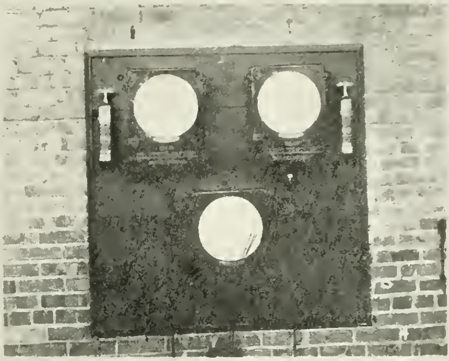
Fig. 7

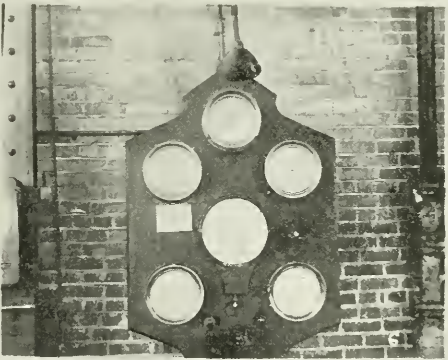
Shows method of connecting tachometer stand to the blowing engine with flat belt drive. The flexible capillary tubing is the lead from the stand to the recording instrument.











must keep his pressure constant; a recording thermometer on the feed water line; and a recording steam temperature thermometer.

In the power house proper are recording pressure gauges to show the pressure of the steam from the boiler house, and the circulating water to the condensers. The condenser temperatures are also recorded; the incoming cold water, the outgoing tail water, and incoming exhaust steam. For these a three-pen recording thermometer is used, which furnishes the three records on one chart for ready comparison. In addition to this a recording vacuum gauge is installed in connection with each condenser.

As previously stated, the speed of the engines is varied with the atmospheric temperature changes, and a recording tachometer on each engine helps the engineers to make these variations occur at the right time and in the correct increments, as the case may be. The revolving mechanisms of the tachometers are belted to the main driving shafts of the blowing engines which are of the horizontal type built by Mesta Machine Company.

The operations of the bells and skips are shown on a four-pen time recorder. This is done by means of an electrical contact actuated by the counterbalance of each bell and which in turn operates the pen on the instrument. There are also contacts on the skip hoist so that the operation of the cars actuate them.

One of the outstanding features of the very complete recording instrument equipment at the Weirton Steel Company is the interchangeability of the pyrometers. Every pyrometer is calibrated for the same external resistance, and each unit connected direct to the fire-end, without using any switches or multiple connections. Thus any pyrometer instrument can be used with any set of leads and fire-end with accurate results.

Another feature of the equipment worthy of mention is the fact that an instrument sufficiently sensitive to record the fluctuations in pressure will continue to operate in the dust filled atmosphere. Each recording mechanism, however, is mounted in a husky dust-proof case, which thoroughly protects them from the excessive dirt always abundant around a blast furnace. One instrument in the boiler house is located at a point where occasionally a regular shower of dust and dirt descend upon it. It is a fact that after the shower is over the dirt is generally about an inch deep on top of the instrument, but the case keeps the inside of the instrument entirely free from dust.

Determination of Benzol in Coke-Oven Gas

The following data and explanations will, we believe, prove to be of interest to our readers, because they show European methods for the determination of the benzol in the coke-oven gas. As, in this country, by-product plants are erected in larger numbers every year, and benzol is one of the most valuable by-products. As it is difficult to obtain reliabe figures in regard to its content in coke-oven gas, the methods described in the present article as well as in those following will not doubt cause a comparison of the methods applied in the U. S. with those of Europe

By A. THAU,
Chief Engineer—Gesenkirchen.

PART I.

Of all the analyses to be made to control and check the operation of the coke ovens, none offers as many difficulties as the determination of the benzol in the gas. These analyses have to be made in short intervals, in order to permit a close supervision of the absorbing action of the benzol-washers. The difficulty in making these determinations can be seen in the fact, that, while all the other chemical investigations to be made in a coke plant, are standardized, the benzol is found in many different ways, as will be proven in the following.

The difficulty connected with the determination of benzol is mainly due to the small quantities of this constituent in the gas, especially in that gas which has passed through the benzol-washers. Besides, benzol is very inactive, and, for this reason, it can not be used in the same way as most of the other gas constituents, for instance, carbon dioxide, ammonia, sulphur, cyanogen, etc., the amounts of which, on account of their high affinity to other chemical reagents, can easily and exactly be determined.

In actual operation the washing process, as far as ammonia, sulphur, cyanogen and recently ethylene are concerned, is based on chemical reactions, whereby a chemical affinity between the washing liquid and the gas constituent considerably facilitates the absorption. These conditions are not given when benzol is to be absorbed. It is true, benzol vapor will be dissolved by the wash-oil, but it will not combine with it chemically.

The whole process is, therefore, nothing but a mechanical solution, which is, along with a number of other circumstances, influenced unfavorably by the very high vapor tension of the benzol and by the moisture contents of the oil. The basic principles, underlying an efficient operation of a benzol plant, are, for this reason, the largest possible diminution of these influences, by drying the gas, and by a low temperature and good quality of the wash-oil. If these principles are not strictly observed, the correctness of the benzol determination must be questioned.

The few operations to determine chemically the quantity of benzol in the gas, have not given satisfactory results. Some investigators (Harbeck and Lunge) determine the benzol as dinitrobenzol. This operation is, however, too complicated for general practice and it is also not free from possible errors. Others (Deenis and O'Neill) recommend ammoniacal nickel-cyanide as a good absorber, but this reagent also dissolves ethylene, thus giving incorrect results.

All these methods have been examined and investigated very carefully, and it has been found that they are valueless for practical determinations. It has been pointed out, that no matter how desirable a volumetric determination would be, on account of its quickness and simplicity, such a procedure is very unreliable because the contraction in volume after absorption is so

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From "Gluekauf," May 28, 1921.

small that it can hardly be noticed. This contraction amounts to only .09 ccm for 3 g of benzol; it is, therefore, hardly visible in the ordinary gas burettes. Even with the instruments for making mine gas analyses, which have a very fine graduation, reliable results could not be obtained when using nickelcyanide.

The ways and means generally employed when making gas analyses, can be divided into groups, in the volumetric group, in which the contraction after absorption is measured of a certain previously determined quantity of gas, and into a group, which permits the passing of the gas through an absorbing agent, in which the gas constituent wanted is determined in different ways.

When making a volumetric determination, which, when executed carefully, gives very good results, the heavy hydrocarbons benzol and ethylene are determined by absorption in fuming sulphuric acid or in bromine water. But the quantity of gas used for the analysis, mostly 100 ccm, is so small in relation to the immense quantities passing through the benzol washers, that the least unnoticeable difference, referred to the total gas quantity, will cause large errors. The results obtained in this manner are, therefore, unreliable.

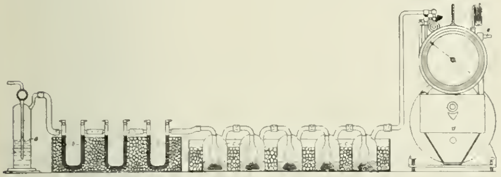


Fig. 1—Complete benzol absorption train after Boennemann.

In Germany, as a rule, small amounts of benzol are absorbed and then determined by weighing them out, whereas in foreign countries large quantities are absorbed, and then distilled out of the absorber and measured. The first-named procedures will be dealt with first in the following.

Especially in those cases, where larger quantities of benozl have to be absorbed, gas wash bottles are employed, which may have different forms and shapes to suit personal ideas. They will not be described below, but only that apparatus will be illustrated which serves exclusively for the benzol determination.

Determination by Weighing of the Benzol—Paraffin-Oil Process.

Since the weighing of ordinary gas wash bottles requires chemical balances of comparatively high capacity combined with sufficient sensitiveness, and since the surfaces and the ground part of the bottles may easily give rise to mistakes, simple potassium tubes are employed for these determinations. The tubes must be provided on both sides with bulbs; on the entering side in order to prevent the aspiration of the contents in case there is a slight draft in the apparatus, and on the other side to prevent the gas from carrying the absorbing liquid away.

The best absorbing agent for benzol is fresh wash-oil, which does not precipitate solid particles when cold, and which, even at a low temperature, remains comparatively easy flowing. Principally used in Germany for this purpose is the clear paraffin oil. Care must be taken when using this oil, because some grades become lighter when air or gas is passed through them, thus showing a content of volatile constituents. It is safest to heat the oil slowly to its boiling point before using in order to drive out the volatile matter.

The tubes are charged with this oil in such a way that the three bottles are half filled. Up to six of these tubes are weighed, after having been charged; they are then put together with their ends so that they touch each other, thus eliminating as much as possible the use of rubber tubing, which also absorbs benzol. The tubes are then placed in a large tin box and surrounded entirely with small pieces of ice. The total arrangement is about the same as that of Boennemann described below and illustrated in Fig. 1.

The gas must pass through the apparatus so slow that the different gas bubbles become visible separately and independent of each other in the different bulbs as they pass through the oil. For investigations which require great correctness, a flask holding between 15 and 20 cubic feet and filled with water is used in place of the gas meter. This flask acts as an aspirator, and forces, by means of a syphon, the gas through the apparatus. The quantity of water flowing out of the syphon being measured, it corresponds to the amount of gas aspirated. When determining the total contents of benzol in the gas before it enters the benzol washers, generally 20 to 25 cubic feet are aspirated in between 3 and 4 hours. If the rest of benzol, which remains in the gas after it has passed through the washers, is to be determined, a double quantity of gas is used. After the absorption is finished, the tubes are removed from the ice bath and carefully wiped dry. The gas above the oil is displaced by air and the tubes with their contents are weighed, after they have obtained room temperature. The increase in weight corresponds to the benzol contents in the measured gas quantity. Corrections must be made according to temperature and atmospheric pressure, which must be observed during absorption.

This method has, under the name "paraffin oil method," found a large distribution and many adherents. In the hands of an experienced analyst it gives very good and reliable results, however, there is room for improvements. That part needing improvements the most appears to be the tube proper, which, on account of the numerous uneven surface parts, caused errors in weighing, besides being very fragile. Furthermore, oil can easily be carried out with the gas, even if there are bulbs provided to prevent it.

These objections have been taken care of in the absorption apparatus. The three burettes of the original potassium tube have their original size and shape and they are suspended in a small cylindrical bottle, which is hermetically closed up and provided with a gas outlet tube bent in a right angle. The gas entering tube has a bulb and is rigidly connected with the burettes, being molten into the cover of the bottle, in which the burettes are suspended. The gas outlet tube, which is molten into the cover of the bottle, has no connection with the burettes. The burette from which the gas last leaves, is provided with a thin tube bent downward, through which the gas first enters the bottle, i. e., the space around the burettes before it leaves through the outlet tube. In this way the oil eventually carried along by the gas is retained on the bottom of the apparatus, thus preventing sources of error on account of oil losses. These wash bottles have the advantage, that, on account of their uniform surfaces and their smaller chance for breaking, they can easily be cleaned and dried.

Determination of Benzol, Boennemann's Method.

Similar to the last named apparatus, the benzol absorption bottle of Dr. Boennemann has also even, easily cleaned surfaces on the outside. This advantage is combined with comparatively large diameters of the connecting tubes.

When a determination of benzol is to be made, 5 or 6 of these bottles, filled with oil, are connected in a row, as shown in Fig. 1. The gas passes through as short a tube as possible and enters into the wash bottle "a," containing picric acid, which retains the naphthalene. It then flows through the calcium chloride tubes "b," standing in a box filled with ice, from where it leaves in a completely dried state. The gas passes into the atmosphere, either directly, or by means of an ejector driven by steam or water. The latter arrangement is applied when the gas pressure is too low to overcome the resistances in the apparatus.

Benzol Determination According to Krieger.

During his investigations into the determination of benzol, Dr. ing. Krieger has found that, when gas passes through the oil-filled absorption bottles, oil is almost always carried away with the gas, a condition which naturally influences the correctness of the final results and which, from the start, requires the use of a larger number of bottles than would otherwise be necessary. In order to prevent this, he has tried a number of differently shaped bottles, finally deciding upon a wash bottle, which is formed after the well-known type of Drehschmidt's. This wash bottle is about 22 cm high with a diameter of about 5 cm. The gas outlet connection is not simply connected to or molten into the cover, but in the inside it reaches into a compartment, which has the form of a test tube of 1.2 cm inside diameter and 15 cm in length. In the center of the bottom of this test tube there is a small opening, and about 1.5 cm above this opening there are a number of small holes; through these holes and through the opening, the gas, leaving the apparatus, enters the compartment, which is filled with glass beads of about 2 mm diameter. On the top the compartment is closed by a stopper, through which the gas outlet enters. When the gas passes through the bottle, which is filled with oil up to the mark shown in Fig. 5, the benzol is absorbed in the lower part; the oil, carried away with the gas, is held back by the glass beads in the tube. After a few determinations have been made, the oil collects on the bottom of the compartment and drops through the opening in the center of the bottom back into the absorption bottle. After this has happened, the compartment, before starting a new determination, is washed out with benzol and dried carefully.

According to statements made by Dr. ing. Krieger and verified by the writer, two of these bottles are sufficient to absorb all the benzol. During operation the bottles are standing in an ice bath and they must attain room temperature again, before they can be weighed. Besides, the air contained in the bottles must be replaced by dried gas. But since, after absorption, the gas diffuses out, without replacing the air entirely, the bottles are connected after absorption to a gas line in the laboratory, during which time the gas outlet is closed by suitable means (rubber tube and pinch cock). After room temperature is reached, the rubber tubing is taken off, the bottles wiped off carefully and weighed. If these things are not carefully watched, errors in the bottles can easily happen, which make the analyses worthless. It must, however, be said that cork stoppers have, according to the writer's experience, not given satisfactory service, because the porous cork shows a continuously varying contents of moisture, which influences the results considerably. Only after rubber stoppers had been employed, which had a coat of waterglass on the bottom, to prevent the gas from coming in contact with the rubber, have satisfactory results been obtained.

(To be continued)

LUBRICATION OF ROLLING MILL PLANT

In an article by F. Linzen, which recently appeared in Stahl and Eisen, the following appeared:

The author writes as the result of a lengthy experience of the running of rolling mill plant. As regards the lubrication of rolling mill engines, this offers no difficulties, the central forced system being probably the best, as in addition to thorough working safety it has the advantage that the oil can be admitted liberally without fear of waste. In one works to which the writer refers there is a central "oil-treating" system, which collects all the dirty oil from the various machines and pumps cleaned or fresh oil. In this method, the oil is never touched by hand at all. Every machine has a clean and a dirty oil pipe to and from the central plant, and a signalling device. All the dirty oil from the machines runs into a tank, being pumped thence to the central station. The oil passes through a graduated measuring vessel before being pumped to its destination.

As regards lubrication of the gearing, all kinds of grease had been tried and have been abandoned in favor of oil, as the wear of the working parts was very considerable with grease lubrication. All the pinion bearings are lubricated with oil, and the pinions themselves with grease rendered less viscous by the addition of oil. In the mills he is referring to, the bearings of the slow-running ingot trains are fitted with wick lubricators, and the large finish mills with ring lubricators. In the smaller mill trains, i. e., from about 22 inches downwards, the following system of lubrication has proved satisfactory: On the housing of the pinions is an oil tank, which distributes fresh or cleaned oil to every ring-lubricated bearing, the flow being capable of regulation. The pinions are separately lubricated on the overhead flow system, oil being sucked up from the closed casing by a geared pump driven from the pinion spindle and then allowed to splash from the top on to the pinions, so that the oil is continually circulating during the rolling operation. The gear-wheels of the continuous mill-trains are lubricated in the same way as the pinions, the circulation being continuous in this case also and driven by geared pumps.

Oil lubricatoin, where feasible, in place of grease lubrication, necessitates less attention, and, as mentioned above, reduces wear. A comparison of the two systems of lubrication at the writer's works showed that a grease-lubricated 240 mm diameter bearing, 400 m long, which had been running for three years, revealed a wear in the bearings of 4 mm and of 2.9 mm at the journal; whereas, with oil, the bearing wear was only 1.2 mm, and the journal wear 0.2 mm after three years' running at a speed of 120 rpm.

The Logic of Roll Design

Discussion on Particular Features of Roll Design Such as the Determination of the Maximum Draft on Each Pass and the Determination of the Minimum Diameter of the Rolls.

By **W. H. MELANEY.**

PART IV.

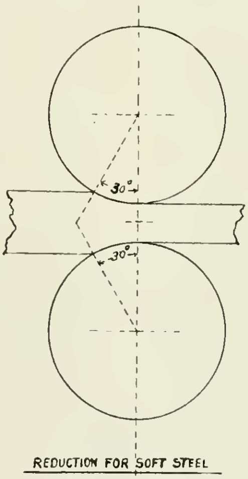
THE writer has been requested to answer the following questions on roll design:

1. With a given ingot to be reduced to a bloom in a given number of passes, how to determine the maximum draft on each pass?
2. How to determine the minimum diameter of rolls either with two or three high mills, and whether or not there is a stated formulae for this work.

In answer to 1, the writer wishes to state that in his judgment the maximum draft that should be used at a pass, is that which will permit the ingot to enter the rolls without ragging or knurling the rolls. For no matter how carefully this ragging or knurling is done the effect on the surface of the steel is deleterious, although in some instances it is permissible.

For instance, in very soft steels that can be finished at a fairly high heat, this ragging permits greater speed in rolling, because the draft can be increased per pass, or the rolls can be run at a greater number of revolutions per minute and still permit the steel to enter easily. If the ragging is correctly done by using a blunt knurling tool, the marks left thereby will usually roll out on the softer grades of steel under future reductions without visible injury to the finished bar.

But on hard steels such as tool steel, whether the hardness is due to carbon or alloy, the practice of ragging should never be resorted to. One reason why rolls for rolling hard steels have much lighter draft than those for softer steels is due to the fact that the bar offers greater resistance in entering the rolls, and either the draft or the speed of the rolls must be reduced in order to permit it to enter without ragging. In the case of hard steels the effect of the ragging would be carried through to the finished bar, showing a seemed or cracked surface when magnified.



REDUCTION FOR SOFT STEEL

As stated in a previous article, the usual method of determining the maximum draft on soft steels for any diameter of roll is that shown in the accompanying illustration where the angle of contact does not exceed 30 degrees as shown. This will require no ragging, but on hard steels this draft must be reduced in proportion to the hardness and the decrease of heat at which this steel must be rolled, and usually represents a reduction in draft 50 per cent less than softer steels.

So far as the writer knows there is no hard and fast rule governing this process, and considerable judgment must be used in determining all the conditions that exist in every special case. However, the above specifications will successfully take care of general conditions.

It will be noticed that rolls as usually designed do not reduce the ingot at a given percentage of decrease of area at each pass, and this is due to the fact that particular sizes of billets are required to be produced in the usual run and this may require a greater or less draft to be used on a second or third pass than was used on the first.

While it is entirely practical to reduce a given size of ingot by using the maximum draft for that portionate reduction for each pass all the way down, this is rarely, if ever, done in practice, and could only be used where a given ingot was to be reduced to a given size of bloom in the least possible number of passes, irrespective of any other consideration and even then the conditions would be more or less modified by the quality of the steel and the temperature at which it was rolled.

The softer steels which will stand a good soft heat in rolling being susceptible to greater abuse from excess draft obtained by ragging the working surface of the rolls, which would permit of an increased draft in some instances of 25 per cent.

The conditions cited above apply only to the reduction of an ingot in open passes, as in all other forms of rolling in enclosed grooves the draft will be contingent upon the shape of the groove, the amount of slabbing action that can be produced in the groove, and its capacity to take care of overfill without objectional finning.

How to Determine the Minimum Diameter of Roll to Successfully Reduce a Given Sized Ingot.

We will first consider this question based on the use of three high rolls as the assumption is that these rolls would be fixed in a stated position on the center line and, therefore, form a set of positive grooves, with a given reduction on each pass, and susceptible of very slight adjustment, therefore the groove would have to be cut into each roll to a depth sufficient to admit the ingot or bloom with the amount of draft previously decided upon.

Then the size of ingot to be rolled and the groove in these rolls having the smallest diameter and which is usually the first groove, will determine the proper diameter of roll to be used for this purpose (assuming commercial sized ingots are to be rolled). As the deep groove in this case would be on the end of the roll near the neck bearing, and if it becomes necessary to have two such deep grooves, which sometimes happens, then the second deep groove, if practical, is placed at the other end of the roll near the other neck bearing, thus permitting the grooves in the center of the roll to be larger in diameter, making a stiffer and stronger roll than would result if the deep grooves were placed farther away from the neck bearings.

Under conditions as outlined above, the minimum diameter of the deepest groove should not be less than the diameter of the neck of the roll, and in usual practice should exceed this diameter by at least 10 per cent.

This same rule would apply to two high mills if both rolls were fixed at the center line with no adjustment of the top roll. The conditions then would be the same as on the three high mills.

On two high mills with a top roll that can be raised or lowered, such, for instance, as a reversing blooming mill, and which is the most desirable method of reducing an ingot, this rule does not apply.

In rolls of this type it is only necessary to have a groove deep enough to properly hold up the ingot or bloom and prevent it from assuming a position that would cause the top and bottom of the ingot to become out of square with its side. If this should happen it is extremely difficult to square it up again without employing some exterior means of holding the ingot up, until the faces have been brought back to a right-angle turn. If this condition were permitted to go on, the bloom would finally turn over in rolling. On the ordinary blooming mill roll these grooves will vary in depth from 3 inches deep on the larger grooves to 1¾ inches deep on a groove for rolling a 4-inch billet. The top roll being raised sufficient to admit the larger size of ingot and then lowered on the succeeding passes to produce the size of bloom or slab desired. Mills of this type usually range from 30 inches diameter by 70 inches long to 45 inches diameter and 96 inches long, the two more popular sizes being 35-inch and 40-inch mills.

While so far as the writer knows there has never been any formulae or rule definitely accepted for determining the size of neck for any given diameter of roll, successful rolling mill practice has demonstrated that certain standards have been pretty closely adhered to in determining this question and have produced very satisfactory results.

However, due to the radical difference in conditions that exist in the various types of rolling, it has been found necessary to separate them into four distinct classes.

Class 1. Guide mill, bar mill and structural mill rolls in all of which the roll necks are kept drenched with water during the rolling process and, therefore, prevented from heating so that they run practically cold and are easily kept lubricated. Therefore a smaller diameter of neck may be used advantageously.

Good practice has shown that on mills of this type rolls from 7 inches diameter up to and including 16 inches diameter should have necks of a diameter equal to five-eighths the pitch diameter of the roll, or pitch diameter × 0.625 = diameter of the neck. And above 16 inches diameter of roll the neck should have a diameter equal to two-thirds the pitch diameter of the roll, or pitch diameter × 0.67 = diameter of the neck.

Class 2. Plate mills which produce wide plates of various thickness, usually from 3/16 inches thick and over, and are, therefore, subjected to greater strain than bar mills, but the necks of which can also be kept drenched with water so that they run comparatively cool.

In mills of this type the neck should have a diameter equal to three-fourths the pitch diameter of the roll, or pitch diameter of roll × 0.75 = diameter of the neck.

Class 3. Sheet and tin mills which are called upon to produce wide sheets of light gauge and which, due to the nature of their product, must be run hot, and as there are usually a number of these mills connected in a straight line to the same drive and must withstand not only the rolling strain, but severe shock from back lash, together with the difficulty of keeping these hot necks properly lubricated, and the fact that the roll next to the drive must transmit all the power for the other stands connected to it, practice has demonstrated that the neck on this type of roll should be eight-tenths the pitch diameter of the roll, or pitch diameter × 0.8 = diameter of neck.

Class 4. Reversing blooming mills used for reducing ingots to blooms and which can be run under more favorable conditions than any of the other types, having only one piece of steel in the rolls at any one time, and this can be kept with little difficulty at a good hot rolling temperature. Therefore, the necks do not have to be so large in diameter as either of the other types, as they are easily kept lubricated.

General practice has shown that nine-sixteenths the pitch diameter of the roll gives a very satisfactory diameter of neck for this type of roll, or pitch diameter × 0.5625 = diameter of the neck.

These formulae have been based upon prevailing sizes of necks in common use at mills considered to have good practice and the size of these necks were generally determined by the cut and try method by increasing the size of neck until a diameter was arrived at, that would stay in the game on that particular class of work, without serious trouble or breakage.

Therefore, they have the redeeming virtue of having been proven out in practice.

A roughly approximate rule for determining the pitch diameter of a three-high mill with positive grooves, suitable to reduce a given size of square ingot or bloom is 2½ times the thickness of bloom equals the pitch diameter of the mill required.

In the next article the proportion of wabblers to the size of neck for the various types of mills, will be considered.

THREE CHARCOAL FURNACE PROJECTS UNDER WAY

In addition to the plan considered by the Ford Motor Company for building a charcoal blast furnace near Negaunee, Mich., two other charcoal furnaces are contemplated by other interests, according to Skilling Mining Review, of Duluth. The proposed sites are on the Menominee iron range. The Mining Review states:

"One of these projects is in the hands of M. E. Richards, formerly in charge of the Judson mine, and earlier than that interested in Mesabi range properties. Associated with him are some hardwood lumber manufacturers, and the plan is to secure money for the erection of a furnace of approximately 100 tons capacity."

The other project, according to the Mining Review, is that of Iron Mountain interests who hope to connect a blast furnace with ore deposits adjoining the Chapin mine.

Modern Drop Forge Plant Completed

The Pittsburgh Knife and Forge Company's New Plant at Coraopolis, Pa., Incorporates Latest Ideas In Design for Production of Special Parts — Complete Plant Layout Given.

By E. C. COOK.

IT is common knowledge that the drop forging industry has grown at an amazing rate during the past few years. Several figures recently published by the United States Department of Commerce in the Census of Manufacturers will emphasize this point better than any other statement or series of statements which the author might make. Their report reads as follows:

	Number of Establishments	
	1919	1914
Iron and steel forgings not made in steel works or rolling mills..	240	191
	——Value of Products——	
	1919	1914
Iron and steel forgings not made in steel works or rolling mills..	$171,676,000	$28,961,000

From these figures we see that in the past five years the number of forge shops has increased about 25 per cent. This might be considered a rather small increase, but when the value of the product is considered, the matter appears in quite a different light. From approximately $29,000,000 in 1914 to $172,000,000 is quite an increase. In fact, if we stop to figure it out, it will amount to about 600 per cent. The question is naturally asked: What is the reason for this enormous increase in the production of forgings? Those familiar with drop forgings will immediately say the automobile. This statement is very largely true, for it is primarily due to the increased use of automobiles that drop forgings have gained such prominence.

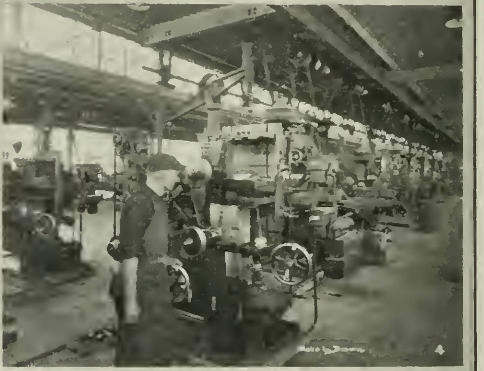
Exterior view of new drop forge plant of the Pittsburgh Knife & Forge Co. at Coraopolis, Pa., showing water tower. The forge shop is located at the right and the boiler house in the foreground. In justice to the Pittsburgh Knife & Forge Co. it must be stated that this cut does not do their plant credit, as an elevation could not be found from which a good picture could be secured.

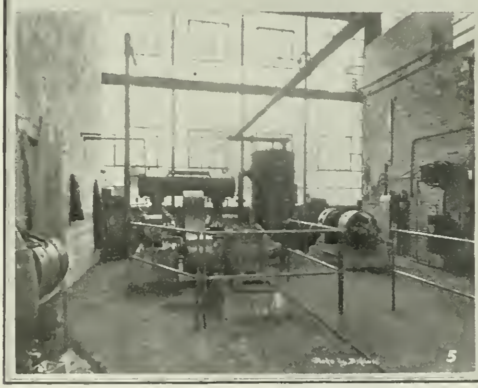
The statement which was made in a recent issue that drop forgings have been bought and not sold is too true. Every manufacturer who was in position to make drop forgings had orders thrust upon him, and the industry prospered amazingly. The demand was such that a great number of new plants were built. One of the very newest of these plants—in fact it is scarcely completed at this time—is that of the Pittsburgh Knife & Forge Co. at Coraopolis, Pa. Formerly located on the banks of the Ohio river in Lower Allegheny, this company found itself cramped for room. With little chance to acquire additional property, and that property so expensive as to make its purchase a very questionable move, the Pittsburgh Knife & Forge Co., as so many other manufacturing plants have been doing recently, determined to locate at a little greater distance from the city. After considerable investigation, 14 acres were purchased on the main line of the Pittsburgh & Lake Erie Railway, 12 miles from Pittsburgh. This property extends from the railroad to the Ohio River. At this point, the writer wishes to digress long enough to question the reader: As a student of economics would you consider such a purchase advisable?

Slightly less than half of the property is covered by the present plant. In preparation for this plant, the ground level had to be raised above high water mark. For this purpose approximately thirty thousand cubic yards of pulverized slag were used as fill. This was only sufficient to bring the ground level of the present building up to the desired elevation. The remainder of their property will be brought up to this level by dumping ashes from the boilers and similar refuse at advantageous points.

This plant was designed for the purpose of producing approximately thirty thousand to forty thousand tons of forgings per year. The output to be sold chiefly among the automotive, tractor, railroad and mining industries, while its shear knives will be sold among rolling mills and other plants which might have occasion to use them.

The idea pursued in designing this plant was to provide a layout which would permit of extension of any of the departments without interference with the general plan of installation, and the arrangement of machinery was made with the idea of reducing operating cost to a minimum and at the same time providing for more or less special items of forgings which this company produces.





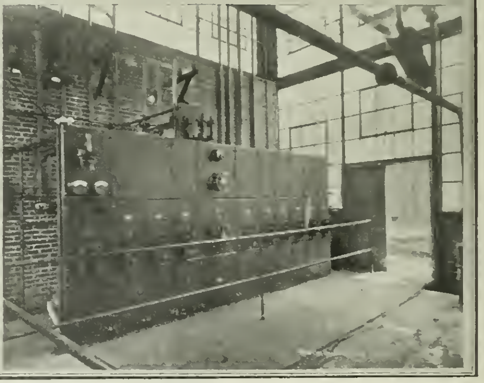


Fig. 1—View of repair department in the machine shop, Pittsburgh Knife & Forge Company, showing lathes and planers used in making repairs on all shop equipment.

Fig. 2—View from upper end of die sinking department showing Becker typeless die sinking machines in foreground.

Fig. 3—Showing open side planer making repairs on hammer base. This is a particularly difficult job.

Fig. 4—Close-up view of Keller automatic die sinker.

Fig. 5—Chicago Pneumatic Tool Company air compressor used for supplying all the compressed air used in the plant.

Fig. 6—General Electric Company switchboard. Particular attention is called to the great number of windows in this plant.

An inspection of the plant layout, Fig. 13, will give a very good idea of the plans pursued in effecting this arrangement. On one side is the forge shop proper with the steel storage at the upper end, through the center of which runs a spur track. Opposite the forge building is the machine shop, including die room, repair department, inspection department, offices, and the power plant. This building is served by two spurs, one running parallel to the boiler house for the purpose of dumping coal, and the other running along the inside of this building at such an elevation that the finished forging may be loaded directly into box cars by means of electric trucks from the inspection department. There is an alleyway, 45 feet wide, between the forge building and the building used for machine shop and other auxiliary purposes. This is primarily for the purpose of not interfering with the air circulation. This space may also be utilized as a storage for forgings.

The Forge Shop.

The forge building proper is 65 feet wide by 700 feet long, 30 feet to the crane rail and 63 feet to the top of the monitor. Construction work was done by the Memphis Construction Company and is essentially of brick and fabricated steel. Particular attention is called to the number of windows which permit easy ventilation and abundant light. Along both sides are sliding doors which can be raised to a height of 12 feet in the summertime, thus making conditions as comfortable as possible for the workmen. Of this building, 420 feet are utilized as the forge shop, and the other 280 feet as the steel storage yard. The entire building is served by a ten-ton crane, which will handle any of the equipment in this building with the exception of hammer bases. The crane is equipped with magnets and scales, and is also used for unloading steel, handling scrap and other work of this nature. A trench 30 inches wide and 24 inches deep extends along the wall all around the inside of the forge building. In this trench are placed the water lines, high pressure air lines, oil line and steam lines. The trench is connected with the main sewer every 40 feet to take care of water and condensation. One feature to which particular attention is called is the manner in which oil is kept warm in the winter time. The three-inch oil line and the four-inch steam line are bound together with pipe covering, thus assuring the fact that the oil will flow freely during cold weather.

It was at first planned to use gas for heating the furnaces, but the shortage of natural gas in the Pittsburgh vicinity made this impossible. Consequently oil is used in all the furnaces. An 18,000-gallon oil storage tank is located under ground in the alley way between the two buildings, as will be seen in Fig. 13. In the stock yard are located two Williams & White and a Buffalo Armor Plate shear. The metal is unloaded from cars or taken from stock to the shears, where it is cut to length, and then taken to the hammer or press on which it is to be forged.

Looking down the forge shop from the upper end, the board hammers are located on the right (Fig. 8) with their accompaniment of heating furnaces and presses. From the trimming press the parts are loaded into steel containers, which are picked up by the electic trucks and taken to the inspection department, where they are inspected and ground preparatory to shipping. As will be noticed, four pickling tanks are located in the corner of this building, where the stock will be pickled preparatory to forging. Seven Chambersburg board hammers, ranging in size from one thousand to two thousand five hundred pounds, are driven by two 50-hp motors with the line shaft carried on one side of the building. Extra heavy pipe is used as a bracing between the hammers and line shaft. Six panel boards in this building take care of all motors. They are 8 feet above the floor along the wall with underground conduit running through each machine. Each machine is controlled by a push button type switch and no operator is permitted to handle any of the switches on the panel board. Opposite the board hammers are located the steam hammers (Fig. 7), a list of which will be found under the layout (Fig. 13). A 12-inch steam line supplies the hammers at 125 pounds pressure, and a 15-inch line takes care of the exhaust steam which returns to a hot water heater in the boiler room and through which the steam is exhausted into the air. During the winter months the exhaust steam is used for heating the offices, inspection department, machine shop, etc. The heating furnaces are all of their own construction, the air blast for same being supplied by eight Spencer blowers, each of which produces 6,750 cubic feet of air per minute at one-pound pressure.

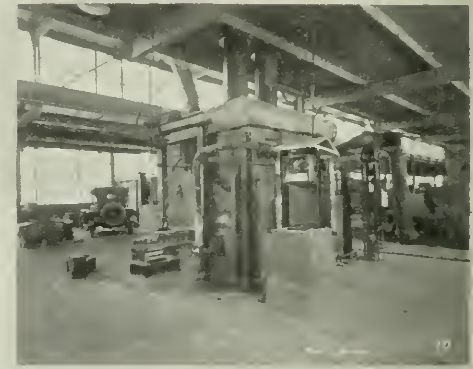
These blowers are placed over the shop office on one side and the lavatory on the opposite side of the forge shop; four on each side. This arrangement provides spare capacity in case any blower should be down for repairs. It further places the blowers in a central position with regard to the entire length of the forge shop, thus giving a more uniform air pressure. The blast pipe is carried overhead along the side of the building. The lower end of the forge shop is not as yet in operation. Therefore, all that can be said about it at this time is that it has been designed and arranged for production work on several special types of automobile and railroad forgings.

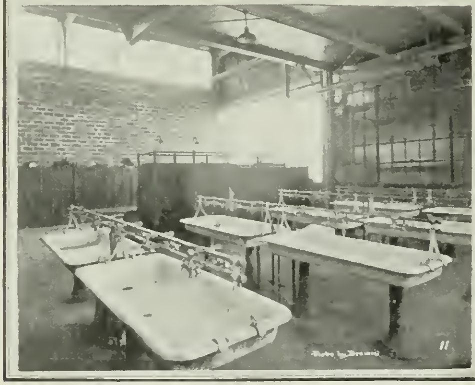
Die Sinking Department.

The building utilized for machine shop and other auxiliary purposes is 70 feet wide by 420 feet long and is 15 feet high under roof girders. It has a 4-foot brick wall with steel sash to roof and a monitor type roof with ventilating sash. The die sinking department, Figs. 2 and 4, occupies the southwest corner of this building and includes four Keller automatic die sinking machines, a close-up of one being shown in Fig. 4. A 40-inch Lodge & Shipley lathe, a Pedrick & Ayer milling machine, a 34-inch boring mill, a No. 3 Becker die sinker, five No. 3 Pratt & Whitney die sinking machines, several lathes, a Brown & Sharpe grinder and a Keller universal grinder are found in this department. To facilitate handling of material to the various machines in this department, a 1½-ton hand crane is placed overhead. Approximately 200 feet at the lower end of this side of the building is occupied by the die sinking department.

Repair Department.

Directly opposite the die sinking department is the repair department (Figs. 1 and 3), which is equipped with a number of large lathes and planers. Attention is invited to Fig. 3, in which a 36-inch Cleveland open-side planer is being used to square up the hammer base. A 1½-ton crane, similar to the one in the die sinking department, is located in this department.





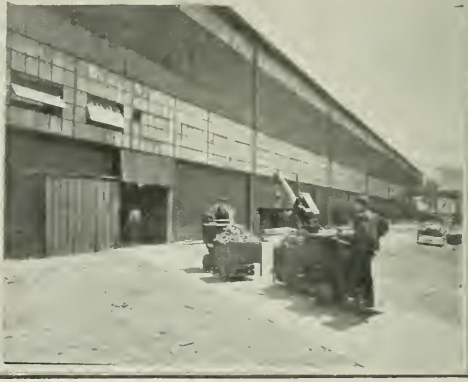


Fig. 7—View of steam drop hammers from the upper end of the forge shop.

Fig. 8—The other side of the forge shop showing board hammers.

Fig. 9—Rail anchors are made on two Toledo presses, which are fed by a continuous furnace of their own design.

Fig. 10—Tate-Jones die block furnace with Leeds & Northrup potentiometer, recorder and controller in the foreground.

Fig. 11—Wash room for convenience of the workmen. It is well equipped with lockers, showers and wash stands.

Fig. 12—Several Automatic Transportation Company electric trucks used in carrying material from the forge shop to the inspection department and from the inspection department to the loading platform. This figure also shows the sliding door which can be raised to a height of 12 feet.

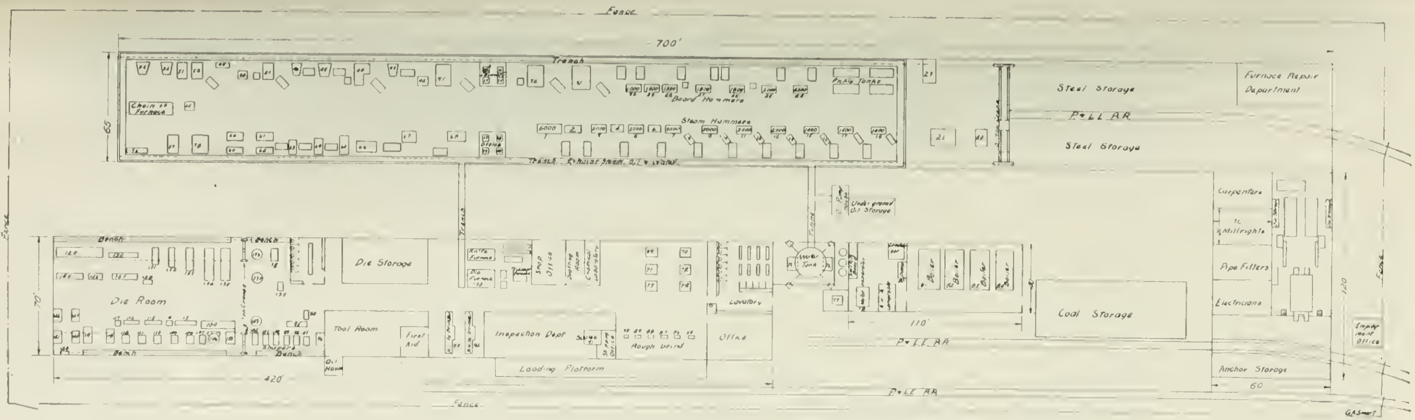


Fig. 13—Layout of Pittsburgh Knife & Forge Company's new plant at Coraopolis, Pennsylvania.

1. 6000 lb. Erie Steam Hammer
2. No. 7 Williams & White Press
3. 5000 lb. Chambersburg Steam Hammer
4. No. 6 Williams & White Press
5. 5000 lb. Chambersburg Steam Hammer
6. No. 6 Williams & White Press
7. 3000 lb. Erie Steam Hammer
8. No. 57 Toledo Press
9. 3000 lb. Chambersburg Steam Hammer
10. No. 57 Toledo Press
11. 3000 lb. Chambersburg Steam Hammer
12. No. 54 Williams & White Press
13. 2000 lb. Chambersburg Steam Hammer
14. No. 54 Williams & White Press
15. 1500 lb. Massillon Steam Hammer
16. No. 4 Williams & White Press
17. 1500 lb. Massillon Steam Hammer
18. No. 56 Toledo Press
19. 1500 lb. Massillon Steam Hammer
20. No. 56 Toledo Press
21. No. 40 Williams & White Shear
22. No. 10 Buffalo Shear
23. No. 11 Williams & White Shear
24. 2500 lb. Chambersburg Board Hammer
25. 2000 lb. Chambersburg Board Hammer
26. 1800 lb. Chambersburg Board Hammer
27. 1800 lb. Chambersburg Board Hammer
28. 1500 lb. Chambersburg Board Hammer
29. 1400 lb. Chambersburg Board Hammer
30. 1000 lb. Chambersburg Board Hammer
31. 6-inch Ajax Upsetter
32. 5-inch Acme Upsetter
33.
34.
35.
36. 8—Spencer Blowers to deliver 6,750 cu. ft. of air at 1 lb. per min. each.
37.
38.
39.
40.
41. 4-inch National Upsetter
42. No. 2½ Chambersburg Press
43. 80-lb. Bradley Hammer
44. 4-inch Ajax Upsetter
45. 500-lb. Bradley Hammer
46. 300-lb. Bradley Hammer
47. 3-inch Acme Upsetter
48. No. 2½ Chambersburg Press
49. 4 Spindle Rockford Drill Dress
50. 2-inch Ajax Upsetter
51. Upsetter
52. 80-lb. Bradley Hammer
53. 60-lb. Bradley Hammer
54. Chain Furnace
55. Eye Bender
56. 6-Spindle Foote-Burte Drill Press
57. No. 27 Williams & White Bulldozer
58. Tate Jones Continuous Furnace
59. No. 12 Williams & White Shear
60. Queen City Shear
61. No. 12 Williams & White Shear
62. No. 13 Williams & White Shear
63. No. 23 Williams & White Bulldozer
64. No. 4 Williams & White Bulldozer
65. No. 5 Williams & White Bulldozer
66. No. 59 Toledo Press
67. 1500 lb. Chambersburg Blacksmith Hammer
68. 3500 lb. Chambersburg Double Frame Blacksmith Hammer
69. No. 57 Toledo Press
70. No. 57 Toledo Press
71. No. 56 Toledo Press
72. No. 56½ Consolidated Press
73. No. 2½ Chambersburg Press
74. No. 3 Chambersbnrg Press
75. Cook Pump 200 gal. per min.
76. Cook Pump 200 gal. per min.
77. Sub-station 22000 Volt Transformer
78. 75-hp Reliance Motor-Generator Set
79. Chicago Pneumatic Air Compressor
80. National Feed-Water Pump
81. 216-hp. Uniflow Boiler
82. 216-hp Uniflow Boiler
83. 216-hp Uniflow Boiler
84. 216-hp Uniflow Boiler
85. Rough Grinding Stand
86. Rough Grinding Stand
87. Rough Grinding Stand
88. Rough Grinding Stand
89. Rough Grinding Stand
90. Rough Grinding Stand
91. 3000 lb. Toledo Automatic Scales
92. Springfield Grinder, 16-foot Table
93. Springfield Grinder, 16-foot Table
94. No. 2 Robertson Hack Saw
95. 21-inch McCoy Brandt Lathe
96. No. 2 Diamond Die-Surface Grinder
97. 16-inch Baird Shaper
98. 24-inch Eberhardt Shaper
99. 24-inch Eberhardt Shaper
100. 32-inch Eberhardlt Shaper
101. 32-inch Eberhardt Shaper
102. 32-inch Cincinnati Shaper
103. 13-inch Prentice Drill Press
104. 40-inch Lodge & Shipley Lathe
105. Pedrick & Ayer Milling Machine
106. 34-inch Rogers Boring Mill
107. No. 3 Becker Die Sinker
108. No. 3 Pratt & Whitney Die Sinker
109. No. 3 Pratt & Whitney Die Sinker
110. No. 3 Pratt & Whitney Die Sinker
111. No. 3 Pratt & Whitney Die Sinker
112. No. 3 Pratt & Whitney Die Sinker
113. 18-inch Bradford Lathe
114. No. 3 Brown & Sharpe Grinder
115. 18-inch Bradford Lathe
116. 18-inch Baird Lathe
117. Small Tool Grinder
118. No. 5 Becker Die Sinker
119. No. 6 Becker Die Sinker
120. No. 4 Keller Automatic Die Sinker
121. No. 4 Keller Automatic Die Sinker
122. No. 4 Keller Automatic Die Sinker
123. No. 4 Keller Automatic Die Sinker
124. Keller Universal Grinder
125. 24 inch Schumacker Lathe
126. Acme Bolt Threader
127. 27-inch Wicks Lathe
128. Webster Perks 14-inch Grinder
129. 40-inch Lodge & Shipley Lathe
130. 40-inch Wright Lathe
131. 32-inch Putnam Planer
132. 30-inch Woodward & Powell Planer
133. 40 inch Cincinnati Planer
134. 30 inch Gray Planer
135. 36-inch Cleveland Open Side Planer
136. 20-inch Drill Press
137. 13-inch Baker Drill Press
138. 32-inch Cincinnati Shaper
139. 24-inch Peerless Hack Saw
140. 24 inch Peerless Hack Saw

CARPENTERS' EQUIPMENT

1 Wood Turning Lathe
1 Power Rip Saw
1 Shaper
1 Bank Saw

MILLWRIGHTS' EQUIPMENT

1 Hack Saw
1 Lathe
1 Bolt Threader
1 12-inch Grinder

PIPE FITTERS' EQUIPMENT

No. 9 Jarecki Pipe Threader
3-inch Bulldog Ratchet Die
1 Pipe Vise
1 Hollow Anvil
1 Horn Anvil
2-inch Pexto Roll
2-inch Pexto Crimper
2-inch Pexto Edger
1 Pexto Wiring Machine

ELECTRICIANS' EQUIPMENT

1 18-inch Lathe
1 10-inch Hack Saw
1 10-inch Drill Press

OIL HOUSE EQUIPMENT

2 4" x 4" Triplex Worthington Pumps
2 7½-hp Motors

ADDITIONAL EQUIPMENT

1 Pease Blueprinting Machine
50 Motors, 5 hp to 100 hp, or a total of 1500 hp in use
1 Portable Concrete Mixer
2 Electric Trucks
2 1½-ton Cranes in Die Room
1 10-ton Crane in Forge Shop
1 36-inch Magnet
12 Steel Trucks
1 Spencer Blower, 4,700 cu. ft. Air per min. in Heat-Treat. Dept.

The Inspection Department.

The next 40 feet of this building is utilized as a store room and hospital on one side, and on the other side for die storage. Separated from the rest of the building by a tile wall is the heat treating department, which occupies the next 60 feet of the same building. It is utilized for grinding and heat treating dies and shear knives. Fig. 10 gives an excellent view of the Tate-Jones die furnace, which is automatically controlled by a Leeds and Northrup potentiometer. Not all of the equipment has as yet been installed in this department. Above the heat treating department is located the superintendent's office and draughting room on one side, and the inspection, grinding and shipping departments on the opposite side. This arrangement places the last mentioned departments directly opposite the main runway between the forge shop and the machine shop, thus making it but a short haul for the electric trucks from the hammers to the inspection tables. It is planned to install a mono-rail system for the purpose of carrying parts from the forge department to the inspection department, where a rotary inspection table is located, on which the forgings will be dumped. The inspectors will stand inside this circular table, and, as the forgings pass, they will examine them, tossing same into the scrap or into the bin as accepted parts.

At the present time all parts are carried from the forge department to the inspection department on lift trucks manufactured by the Automatic Transportation Company, Buffalo, N. Y., several of which are shown in Fig. 12. Special containers of their own manufacture are used in this work. After inspection they are again loaded on trucks and automatically weighed on Toledo no-spring scales, and then loaded directly into box cars, the floor level of which is opposite the loading platform. The grinding department is located just beyond the inspection department, and opposite it will be located three Toledo presses, a consolidated press, and two Chambersburg presses. In the end of this building are located the general offices and the wash room, which is shown in Fig. 11. The wash room is well equipped with metal lockers, showers, wash stands, etc. An instantaneous water heater is another feature of this room.

Pump House.

The water supply is secured from two wells equipped with Cook pumps which have a capacity of 200 gallons per minute. These pumps serve a fifty-gallon overhead storage tank which is noted in the figure on the first page of this article. One pump will take care of all the water needed for the shop, while the other is utilized as a spare. These pumps start and stop automatically at certain levels in the tank. They also keep a pressure of 30 pounds per square inch on the water lines.

Sub-Station.

In the sub-station, several views of which are noted in Figs. 5 and 6, is found a 22,000-volt transformer, the main switch board, Fig. 6 (General Electric Company), 75-hp Reliance motor generator set, a Chicago Pneumatic Tool Company air compressor, Fig. 5, and a National feed water pump. The current for the operation of the plant is purchased outside. The plant is operated on 440 volts ac with the exception of the crane, which is operated on 230 volts dc, and the lighting system, which is served at 110 volts ac. Attention has been called to the lighting of this plant. Figs. 5 and 6 emphasize this feature more particularly than any of the other illustratoins.

The Boiler House.

Next to the sub-station is found the boiler house, which is equipped with four 216-hp Uniflow boilers. These are all hand fired. By referring again to Fig. 13 it will be noted that the coal storage is located conveniently with regard to the boiler house.

Space is also provided for the removal and storage of ashes. When completed the electrician, millwrights, carpenters and pipe fitters will be located as shown in Fig. 13. Next to this department will be located the equipment for making rail anchors, which will include two continuous furnaces, two Toledo presses with oil quenching tanks, reheating furnaces and other necessary equipment. The rail anchors are at this time being made on several Toledo presses as shown in Fig. 9. All floor space will be covered with concrete.

This article would not be complete without referring again to the lighting. The unusual number of windows and the arrangement for ventilation have been mentioned. At night the shop is almost as light as during the day. This is effected by means of a large number of lights located with due regard to shadows in the roof of each building.

The layout and construction of this plant were under the direct charge of Mr. Edwin Hodge, Jr., president; Mr. J. G. Gardner, purchasing agent, and Mr. William Kahn, general superintendent. The other officers and executives of the company are Mr. W. H. Schoen, Jr., vice president; Mr. J. S. Bassett, secretary; Mr. A. R. Bassett, treasurer; Mr. J. A. Egbert, production manager, and Mr. F. W. Strickler, auditor.

NEW EDITOR FOR "MECHANICAL ENGINEERING"

The American Society of Mechanical Engineers announces the appointment as Managing Editor of C. E. Davies to succeed the late L. G. French, who was both editor and manager of the society's publication. The June issue of "Mechanical Engineering" contains a symposium of eulogies on the work of Mr. French, including resolutions of appreciation adopted by the council of the society and by the boiler code committee.

Mr. Davies was graduated from the Rensselaer Polytechnic Institute with a degree of M.E. and for several years afterwards specialized in industrial management work. He became associated with the Smith Premier Works of the Remington Typewriter Company, Syracuse, N. Y., in 1914, and, with the exception of fifteen months during the war, was engaged in production work with that company until March, 1920.

During the war Mr. Davies was in the Ordnance Department at the Frankford Arsenal, serving as assistant production superintendent on the Artillery Ammunition Division and later as superintendent of the fuse shop. He left the service with the rank of captain.

The society has secured for its increasing publication and extensive meetings one especially trained in large diversified business undertakings.

Electric Motor Drive for Traveling Cranes

A General Discussion of Electric Motor Drives for Cranes—The Question of Manual vs. Magnetic Control for Cranes Is Thoroughly Discussed.

By GORDON FOX,
Electrical Engineer, Freyn-Brassert & Co.

PART II.

THE torque and power required to accelerate the motor armature and mechanism may be found from the same formulas as applied for hoisting. This will be found ordinarily to be a relatively small item.

Starting torque is the governing factor in a trolley motor. It should therefore govern the motor selection. The draw bar or tractive effort required in starting, neglecting armature inertia, is

$$DB = \frac{D_f \times D_a \times W}{2000}$$

In order to reduce this to torque at the motor the gear ratio must be determined. The current input in starting may be considered as averaging 150 per cent full load current. This produces, with a series motor, a little more than 150 per cent full load torque. The per cent motor torque for free running condition may then be found by the approximate formula

$$T_f = \frac{D_f}{D_f \times D_a} \times 150$$

Where T_f = per cent full load motor torque at free running or foot-pounds at motor arm

A motor may be tentatively selected by judgment. From the characteristic curves of this motor the speed corresponding to the per cent load torque T_f may be found. Knowing the motor rpm, above, and the free running velocity V of the trolley, the motor revolutions per foot trolley travel N may be found by the formula

$$N = \frac{rpm}{V}$$

The torque T_m at the motor corresponding to draw bar pull DB may now be found by the formula

$$T_m = \frac{DB}{2\pi\ N}$$

This value of motor torque exists during the uniform acceleration period. It may be taken as 150 per cent full load torque of the motor desired. A motor may then be selected whose 150 per cent torque is approximately equal to T_m.

If this motor differs widely from the tentative selection, a check is desirable. However, a line of similar motors does not vary greatly in speed characteristics, so that the method should give results as accurate as the basic assumptions.

If a trolley is to be used for regular cycles of operation the above selection should be based on the 60 minute rating. Moreover, a check on heating should be made. The method will follow closely that outlined for the hoist motion. Since acceleration load is most severe, heating is greatest when short trips are made. The heating depends both on rate and frequency of acceleration.

In selecting a free running speed, acceleration rate, motor size and gear ratio for a man trolley, the necessity and value of speed should be first considered. A little additional speed may represent considerable additional cost. A high free running speed involves a gear ratio less favorable to rapid acceleration, requiring higher motor torque and a larger motor to obtain the desired acceleration rate. It is well to plot velocity time and distance time curves showing advantage of one gear ratio over another. The decision should be based on the average travel or the travel where speed is most important. It will be found that if the average travel distance is short, high free running speeds are of little or no advantage.

The hoisting and racking speeds of a conveying man trolley should be so coördinated that neither causes delay nor is unnecessarily fast. It is well to plot the locus of the moving bucket to see that this represents the shortest feasible distance.

Bridge drives for cranes differ considerably in layout, depending upon the character of the crane. In the ordinary overhead traveling crane one motor is mounted on the side of one of the girders. This motor drives a line shaft or "squaring" shaft which, in turn drives the wheels. There are usually two or more gear reductions involved. In cranes of long spans, two motors may be used, located near the ends of the span, both on one girder and driving the same line shaft, operating in series or parallel. Heavier cranes are frequently equipped with a line shaft on each girder, each line shaft driven by a motor. On small cranes having two wheels on each end truck, half the wheels are driven. On larger cranes having four or more wheels for each end truck, one half or one quarter of the wheels may be driven, depending upon design. The smaller gantry cranes are provided with a single bridge motor, bevel gearing being introduced into the line shaft drive. Large gantry cranes, such as coal and ore bridges are generally constructed to permit skewing and are equipped with separate drives for each leg. These drives commonly operate through wheel traction but cables and winding drums are sometimes used.

The travel speed of cranes and bridges varies over rather wide limits. Obviously, large structures such as coal and ore bridges cannot be moved rapidly. These equipments travel at speeds ranging from 50 to 120 feet per minute. The bridge speeds of overhead traveling cranes are higher than the trolley speeds as the travel distances are ordinarily greater. These speeds range from 175 feet per minute for large ladle cranes to 300 feet per minute or more for fast yard cranes. The usual crane bridge speed, under load, is about 225 to 250 feet per minute.

The load of a crane bridge drive is similar in nature to that of the trolley and has the same component elements. Bridge drive conditions are somewhat more uncertain and less favorable, however. Crane runways are frequently out of alignment, causing excessive flange

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friction. Squaring shaft bearings are liable to some misalignment and excess friction. Cranes are sometimes improperly used for pulling cars or cobbles. These factors introduce abnormal loads. It has been found by test and experience that the friction draw bar pull of a crane with all conditions favorable, will be 20 to 30 pounds per ton whereas a stiff crane and poor track will require about 50 to 60 pounds per ton friction draw bar. Good average practice may be taken as 40 pounds per ton. The torque and power required to overcome friction load may be found by the same formulae as set forth for the trolley calculations, substituting bridge values.

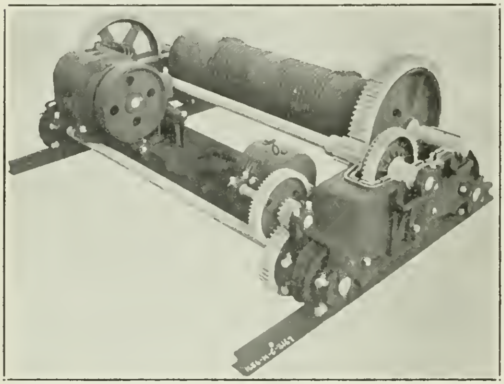

Fig. 2—Showing general arrangement of hoist and trolley drives.

The rate of acceleration of coal and ore bridges is about .5 feet per second per second. Large overhead cranes, gantry cranes or standby cranes are best arranged for acceleration at about 1 foot per second per second. A good average figure for mill and yard cranes is 1.5 to 2 feet per second per second. For very fast service, values up to 3 feet per second per second may be used. It should be noted that an acceleration of 2 feet per second per second is about the limit that can be reached without wheel slippage for a crane having one-fourth of its wheels driven and the weight equally distributed. A crane which is liberally motored and has but one-fourth the wheels driven may tend to slip the wheels excessively. This will run up mechanical maintenance costs. Over motoring is less serious where magnetic control is used to limit current input to safe accelerating values. Uniform acceleration at 2 feet per second per second means acceleration to 300 feet per minute velocity in 2.5 seconds while traveling 6.25 feet.

The torque and power required for acceleration of the bridge motion may be determined from formulae applied to the trolley, adapted to bridge values. The motor acceleration requirements may be determined from the formula already given.

In the case of outside cranes it is customary to figure the draw bar pull due to the wind friction on the basis of 10 pounds per square foot of area exposed in the travel direction. It is not ordinarily expected to operate in winds higher than this value.

The motor size selection and gear ratio determination for the bridge drive may follow closely the method suggested for trolley drive determination. Due to the uncertain elements of bridge friction, it is desirable to have some leeway in the bridge motors.

The use of alternating current motors for crane drives often seems desirable as power is available in that form only. Although the induction motor is not inherently adapted to crane service, it may be made to perform very creditably. For hoisting duty a wound rotor motor is employed. A mechanical load brake or special solenoid brake is used to govern in lowering. Unlike the direct current series motor, the full running speed is closely fixed regardless of load. The crane speed should be determined on the basis of prevailing service which is a partial load condition. If an induction motor be geared for this speed it will cause the crane to have a higher full load speed than the same crane equipped with a series motor and geared for the same light load speed. The induction motor must therefore have about 50 per cent higher hp rating but, if it is also rated for a higher speed, the difference in weights may be minimized.

For driving the trolley motion of small and moderate sized cranes a high resistance squirrel cage motor is popular. This motor is connected directly across the line. But three trolley wires are required. For larger trolleys and for speeds above 125 feet per minute trolley travel, wound rotor motors are used.

A brief comparison of alternating current motor drive and direct current motor drive may be of interest.

A crane equipped with alternating current motors is frequently higher in first cost than a crane equipped for direct current drive. On the hoist motion a mechanical load brake is necessary or a special solenoid brake as above described. On the trolley and bridge drives, starting torque is of great importance, to obtain rapid acceleration. In order to obtain the desired torques larger and heavier motors may be required, if alternating current is used. Increased weight and size of motors necessitates heavier crane members. The cost of a crane equipped with alternating current motors will often run 15 to 20 per cent higher than for a similar crane with direct current drives. Where four or more cranes are involved, this extra cost will about offset the cost of equipment for conversion of the power to direct current.

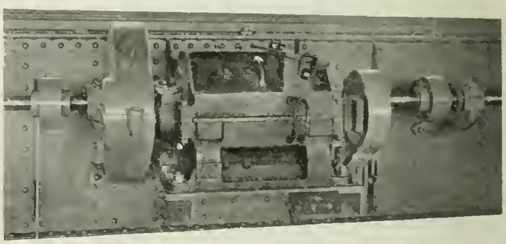

Fig. 3—Showing bridge-drive motor attached to side of girder and driving squaring shaft.

In the matter of reliability there is little advantage. The alternating current motor has no commutator. It has, however, a small air gap. The direct current motor is more easily dismantled for repairs. Slip ring motors are used for all but very light cranes. They require six collectors against four for direct current motors. The control equipment for alternating current motors is frequently more complex. Magnetic control for alternating current involves larger contactors and is fundamentally not the equal of direct current magnetic control.

Crane duty is essentially high torque duty. Alternating current motors are not the equal of direct current series motors in this respect. They require proportionately higher starting currents which are taken at low power factors. The losses are higher than for direct current drive losses, including conversion loss. Where conversion equipment is supplied a high power factor may be maintained.

A great advantage of the direct current crane is in the flexibility of speed and nicety of control. When handling light work a direct current crane will operate at about twice its full load speed. This makes for maximum service from a given equipment. If an alternating current crane is geared for high speeds it will be shy in starting torques unless very large motors are supplied. An altenating current crane has one full speed for all loads.

Direct current control of cranes permits excellent control over a wide range of speeds. In hoisting, a creeping speed with positive torque can be readily obtained. The lowering speed is independent of the hoisting speed and, by means of dynamic braking, lowering can be perfectly controlled and the load decelerated with a minimum of brake wear.

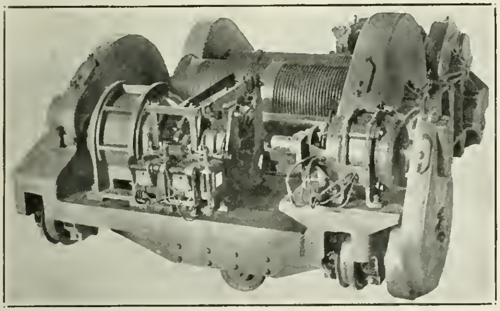

Fig. 4—Trolley equipped with induction motors. The hoist motor is supplied with a two-element brake. One element acts as a holding brake, the other provides variable braking torque in lowering.

Due to the superior torque characteristics of the direct current series motor the acceleration of direct current cranes is usually more rapid than that of alternating current cranes, where compromise is necessary. Thus the direct current crane tends to be a faster all around equipment.

Direct current cranes may be easily equipped for magnet handling whereas a motor generator is necessary to supply a magnet used on an alternating current crane.

The foregoing remarks have dealt primarily with crane motors and their selection. A brief outline of crane control methods and principles follows. As the great majority of cranes are direct current equipped, this type will be mainly considered. The hoist, trolley and bridge control will be considered separately.

Most cranes are equipped with a single hoist motor. Sometimes a straight reversing controller is used with an armature shunt provided in the lowering direction. This has advantage in the matter of simplicity but is open to the disadvantage that lowering speeds with heavy loads tend to be much higher than with light loads. Dynamic braking control is the prevailing type. This permits adjustment of lowering speeds independent of hoisting speeds and also permits adjustment of relative light hook and full load lowering speeds.

Hoist motors are commonly equipped with series wound brakes. When very high lowering speeds are employed, as on coal and ore bridges sufficient current does not flow through the brake circuit to hold it open. It is therefore often necessary, in such cases, to provide shunt wound brakes.

Sometimes two motors are provided for a hoist drive. They are sometimes connected in series but more often in parallel. In case of parallel connection one motor will handle the load at reduced speed. It is well to have such motors oversize, with this end in view. Difficulties may arise, with motors in parallel, due to failure of one motor while running. Also, in lowering, the motors may not divide the load equally unless special provision is made in the control. Some ladle cranes are provided with a ratcheting device which requires the motors to divide the load. Such hoists cannot be lowered with a single motor except by releasing manually the brake or brakes not in circuit.

Alternating current hoist motors provided with load brakes are equipped with straight reversing control. The mechanical brake retards the descending load. A separate solenoid brake is used to decelerate the armature and load and to hold the load suspended. When the adjustable solenoid brake is used, the control is specially adapted.

The trolley motion of the ordinary traveling crane is provided with straight reversing control. No brakes are used. Sufficient resistance should be provided so that plugging on the first point of the controller will not give excessive current nor slip the trolley wheels.

Man trolleys of coal and ore bridges are often equipped with reversing control which may or may not be adapted for plugging. It is preferable that plugging be made safe through use of plugging resistance as this practice must be at least occasionally expected. Solenoid or air operated brakes are used for stopping and holding the trolley. Due to the wear of mechanical brakes when employed for stopping heavy, regularly operated man trolleys, dynamic braking is often preferred. For this purpose the control should be so arranged that the dynamic braking is obtained by short circuiting the reversed armature through the series field and resistance. Braking is then obtained independent of any outside source of power, resulting in a most safe arrangement. A drift point is commonly provided and is of advantage. Solenoid holding brakes are used. When a motor driving a trolley or bridge is to be regularly employed for deceleration by plugging or dynamic braking, this must be considered in determining the heating of the motor.

The bridge motion of a crane is usually provided with a straight reversing controller with two or more speed points. When magnetic control is provided, current limit relays are commonly used to govern acceleration. Time element acceleration offers advantages. It is frequently necessary to adjust current limit relays for high current values to insure starting of the crane at bad points in the track. Time element acceleration insures sufficient torque available for bad conditions yet protects the motor so far as possible for average conditions. Most traveling cranes having fixed cages are provided with foot brakes for decelerating and stopping. When the cage is on the trolley, stops may be made by plugging, the control being properly adapted, or solenoid brakes may be used. In the latter case the shunt brake is of advantage in that a drift point may then be included in the control. Such brakes are subject to considerable wear and are difficult to maintain in adjustment.

In the case of large bridges sudden jerks are to be avoided. Wind conditions must also be considered. If a reversing control is used the first point should be arranged with high resistance to restrict the plugging torque to a safe value. A creeping speed is often provided by shunting the armature or the entire motor. This is used when traveling with the wind. Dynamic braking is sometimes employed, similar to that described for trolley control. Solenoid holding brakes are used. It is suggested that these solenoids be shunt wound because series brakes have been known to drag on light loads and wear the shoes or bands losing their holding power and thus introducing a dangerous condition. Rail clamps are often employed, their control being interlocked with that for the bridge motors. Where separate drives are provided for the trucks at the two ends of the bridge a limit switch is provided to act upon the bridge controller to limit the skewing to a safe amount.

The question of manual vs. magnetic control for crane service is much discussed. Magnetic control is particularly desirable for the larger motors. Sometimes the practice is followed to use manual control on the smaller motors, up to 30 to 50 hp perhaps, and to use magnetic control for the larger motors. This is not strictly logical but may be most practical. Standby cranes may be equipped with manual control in order to restrict first cost. However, if the motors on a standby crane are based on low rates of acceleration to restrict motor size, it is difficult to insure, with manual control, that the operator will not attempt to accelerate rapidly and overload the motors. The general tendency, with manual control, is to accelerate too rapidly, resulting in shock to crane, slipping wheels and overloading the motors. Manual control is satisfactory in the hands of good operators where service is not severe. Magnetic control offers the following advantages:

Protects motors, in a measure, against abuse.
Provides small, compact master controllers which may be accessibly grouped.
Renders operation easier and less exacting.
Relieves operator, enables him to operate more motions. It is necessary on cranes having many complex motions.
Give automatically, maximum safe acceleration, thus aiding to fast operation.
Is safer and more easily maintained, more flexible for special design features.

Electric Furnaces for Making Steel

General Features and Advantages of the Electrode-Hearth Arc Furnaces — Feature of These Furnaces Are That They Have a Single Arc and One Movable Electrode.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART VI

An electrode-hearth arc furnace, in its simplest form, has a single arc and one movable electrode; the furnace hearth itself being conducting and serving as the other electrode. The single electrode form of the Girod furnace see Fig. 26, may be taken as an example. In the electrode-hearth, as in the series-arc furnace, the contents of the furnace serve as one pole of each electric arc, and the electric current passes through these contents. In both kinds of furnace there must be one movable electrode for each arc. The electrode-hearth furnace can be made simpler than the series-arc, as it may contain only one arc and one electrode. It is also simpler to operate because there is only one arc in each electric circuit and thus each arc is independent of the others. On the other hand the conducting hearth is a source of some difficulty, both in construction and maintenance, and the earlier furnaces of this class were operated at lower voltages than the series-arc furnaces.

The Girod furnace, Fig. 26, has a number of water-cooled steel electrodes embedded in the hearth, for completing the electric circuit. A more recent furnace, that of Snyder, has the same construction. The Keller furnace has a conducting hearth made by ramming burnt magnesite amongst a number of iron rods. These furnaces have, in common, the difficulty of repairing the hearth without covering up the hearth-electrode and thus interrupting the electrical connection. In the Chaplet furnace, contact with the hearth is made by an iron electrode which enters the metal in a lateral channel. In this way the difficulty of repairing the hearth is avoided and, also the danger, possessed by the other furnaces, of the steel finding its way through the hearth and causing an explosion when it meets the cooling water.

The furnaces already mentioned are the only ones in which an absolute electrical contact is made to the contents of the furnace, and in which the furnace cannot be started without such contact. We now come to a number of furnaces, with somewhat complicated connections, in which the hearth is actually conducting and carries a part at least of the electric current, but in which the hearth contact is not essential for operation, and the hearth only becomes a conductor when strongly heated.

The earliest of these, the electro-metals, Fig. 27, devised by Gronwall, resembled a Heroult furnace with two movable electrodes, but had, in addition, a fixed carbon electrode in the bottom of the furnace which was covered by the magnesite lining of the hearth. This furnace was supplied with two-phase current, each phase of which was connected to one of the movable electrodes and to the fixed bottom-electrode. When the furnace was cold the hearth was not a conductor and the furnace operated with the two arcs in series, utilizing the effective voltage of the combined phases between the movable electrodes. As soon, however, as the furnace was strongly heated, the hearth became conducting and each phase of the electric current circulated through one movable electrode, one arc and the bottom contact. Later furnaces depend on the same general principle, although metal contacts, not carbon, are now used in the hearth.

The electrode-hearth furnace offers certain advantages as regards steadiness of electrical load and supply of heat to the hearth and lower part of the furnace contents, and in the later varieties, in which no metal rods pierce the hearth, there is no serious drawback to offset these advantages.

The earlier furnaces of all kinds employed single-phase current. With increasing sizes this became unsatisfactory, in view of the usual conditions of electrical supply, and it became desirable to build polyphase furnaces. The Heroult furnace was readily adapted to three-phase current by the addition of a third electrode. The single-electrode furnaces of Girod, Keller and Snyder cannot be adapted to the use of polyphase currents without losing their characteristic simplicity of construction, but the recent forms of electrode-hearth furnace, including the Snyder furnace, are all designed for two-phase or three-phase current. In a later form of the Girod furnace four arcs and four electrodes are used, and the number can apparently be increased indefinitely, using single-phase current and coupling all the electrodes together. It is further possible to use three electrodes and three-phase current by connecting the hearth to one leg of a star-connected transformer system, as in the Greaves-Etchell furnace. The remaining furnaces of this class have either two or three electrodes and an equal number of arcs.

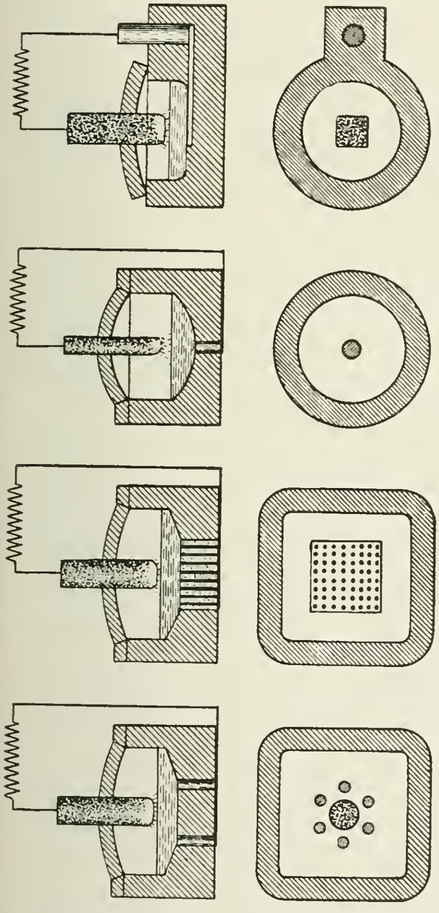

Fig. 26—Diagram of electrode-hearth furnace.

Most arc furnaces of the "direct-heating" type are operated with short arcs, because, with short arcs, the heat is produced closer to the material to be heated and the roof of the furnace is screened better from the heat of the arc by the electrodes themselves than if longer arcs were employed. Comparing furnaces of equal lengths of arcs, and therefore of approximately equal voltage of arc, it will be obvious that electrode-hearth furnaces must be operated at lower voltages than series-arc furnaces, as the latter have two arcs in series while the former have but one arc in each electric circuit. Electrode-hearth furnaces will, on this account, have a lower efficiency as they suffer the thermal and electrical losses of the hearth-electrode and of the cables leading to the bottom contact, while neither of these losses occur in series-arc furnaces.

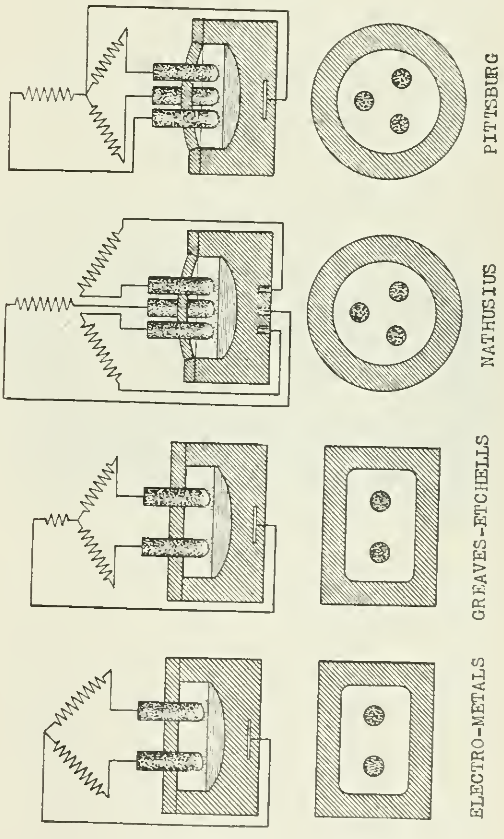

Fig. 27—Diagram of electrode-hearth furnace.

Safety Campaign Waged by Steel Company

Algoma Steel Company at Sault Ste Marie, Ontario, Have Received Gratifying Results From Publicity Campaign on Safety.

THE application of publicity to the solution of the industrial accident problem is the key note of the safety campaign which has been going on in the plant of the Algoma Steel Corporation at Sault Ste. Marie, Ontario, since first of October last. As a net result the campaign has been pronounced a success by the general manager and is being kept up. Thus far there has been a diminution of over 50 per cent in the number of accidents, over 70 per cent in the monthly amount of time lost (thus showing a decrease of this percentage in the severity of accidents). Exact figures are not as yet available as to the decrease in the amount of compensation payable, but it is estimated to be of about the same percentage as the decrease in severity.

The theory underlying the whole campaign is that the personal element is responsible for over 95 per cent of all accidents. Hence, the problem is attacked by educating the human machine. In this eduction reliance is placed absolutely upon the psychological power of the printed word in all its forms—in other words the pulling power of publicity. Use is made of this power to inculcate lessons on safety, the whole to the general effect that thoughtlessness is the cause of carelessness, which, either directly or indirectly, is the cause of all accidents; that neither men nor machines are designed to make or cause accidents; that if men or machines do cause accidents it is because they go out of the beaten track of what they are designed or intended to do; that every accident denotes something wrong with men, methods or materials—but especially with men; because if materials are wrong or methods are wrong it is because men made them so or allowed them to remain so. These safety truths were embodied in pithy form in thousands of posters distributed or posted all over the plant, huge bulletin boards were erected and a house organ, "The Algoman," was founded, with safety as the sole plank of propaganda.

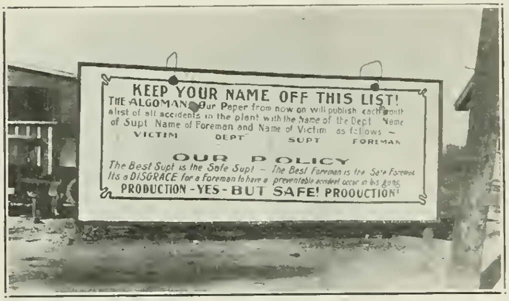
KEEP YOUR NAME OFF THIS LIST!
THE ALGOMAN Our Paper from now on will publish each month
a list of all accidents in the plant with the name of the Dept Name
of Supt Name of Foreman and Name of Victim as follows —
VICTIM
DEPT
SUPT
FOREMAN
OUR POLICY
The Best Supt is the Safe Supt — The Best Foreman is the Safe Foreman
Its a DISGRACE for a Foreman to have a preventable accident occur in his gang
PRODUCTION - YES - BUT SAFE! PRODUCTION!

Fig. 1—"Safety First" board.

The safety department was thoroughly re-organized and a system of mill inspection, as well as accident investigation, instituted. Every unsafe place in the mill, insofar as possible, was guarded; every accident, no matter how small, was investigated by safety inspectors, and a written report made thereon, careful note being taken as to the cause of the accident, whether the carelessness of the victom or someone else, faultiness of the machinery, of the methods of operation, etc.

In every case where pure carelessness was shown to be the cause of the accident, disciplinary methods were adopted.

Throughout the plant and in the columns of the house organ, stress was laid upon the fact that safety was a live issue; that the best superintendent was the safe superintendent; that the best foreman the safe foreman, and that it was a disgrace to any superintendent or foreman to have a preventable accident occur among his men. Moreover, in the columns of "The Algoman," published monthly, a list of every accident was made, giving the name of the victim, the name of the superintendent, the name of the department and the name of the foreman. This had the effect of jacking up everybody, by making it a matter of intimate personal interest to him to avoid accidents.

In order to keep the accident situation constantly before the eyes of everybody in the plant from day to day, huge indicator boards, with sliding thermometric indicators, were erected at every gate in such a position that every man, passing in or out, necessarily sees the exact standing from day to day, each day of the month. These indicator boards are so arranged as to give a comparative view of the situation each day on the same day of the previous month. The theory underlying the erection of these boards is to have everybody in the plant so inclined to think "Safety" at all times that everybody will be more careful; and everybody being more careful, there would, of necessity, be a reduction in the number of accidents. The experience of the Algoma Steel Corporation would seem to have shown this theory to be correct.

In addition to the inspection of mills and the investigation of accidents, the system in the medical office maintained at the plant was also re-organized in such a way that the safety department was placed in possession of a daily report, in writing, showing the number of dressings made on the previous day, the condition of each patient, nature of injury, progress from day to day, with special report in each case on the first, third and sixth day following the accident. These medical reports are filed away together with the accident investigation reports in every case, no matter how slight the accident, no matter whether the victim be off work for one day or one hundred days. Every case is fully accounted for, so that if, at any future time, demand is made for information regarding any accident case in the plant, whether such demand be made by the Compensation Board or any other interested party, the corporation is in full possession of all the facts in the case. The advantage of this is that in the case of claims arising after a lapse of weeks or months, following an alleged accident, full details of this accident (if there was an accident at all) are available, with the name of witnesses, testimony of witnesses, the exact place where accident occurred, the exact time, how it occurred and whether the victim was attended by a physician, and, if so, what the physician's finding was, etc.

Comparative Monthly Statement of Accidents.
From January 1, 1920, to May 1, 1921.
Safety Campaign opened October, 1920.

Month	Average No. Men	No. of Accidents	Days Lost
January, 1920	3,265	63	1,678
February	3,279	45	995
March	3,475	48	945
April	3,388	56	1,109
May	3,166	50	1,123
June	3,090	45	1,040
July	3,012	53	1,202
August	2,993	63	996
September	3,147	61	867
October	3,106	42	605
November	2,884	47	376
December	2,146	29	319
January, 1921	925	3	50
February	2,324	15	153
March	1,700	19	295
April	918	7	*62

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*Estimated disability.

	No. Accidents Per Day	No. Accidents Per No. of Men Employed
January, 1920	2.032	.0193
February	1.483	.0131
March	1.548	.0138
April	1.866	.0165
May	1.613	.0158
June	1.500	.0146
July	1.710	.0176
August	2.032	.0210
September	2.033	.0194
October	1.358	.0135
November	1.566	.0163
December	0.935	.0135
January, 1921	0.097	.0032
February	0.536	.0065
March	0.613	.0112
April	0.233	.0076

FRANK J. McGUE,
Director of Safety.

Campaign's Lessons.

Looking at these figures in their true significance, as regards the men working in the plant, what is the lesson that they convey?

The great lesson is the considerable economic saving effected for the men themselves—in their general well being, their persons, their pockets and their efficiency.

Conservatively estimating the average daily wage earned by the men in the plant at $6, one finds that steel plant employees, during the pre-campaign period, suffered a loss of $59,718 in wages—that is to say—9,953 days lost time at $6 a day, or an average of 1,105 days lost per month, making an average total of $6,630 lost in wages every month.

During the campaign period one finds this $6,630 monthly loss reduced to $1,590—and the figures are still going down.

But, apart from this pecuniary loss to the man, is the general economic loss, both to man and to the corporation, resulting from the disorganization incident to many absences, replacement of absent men, training of new men to fill the gaps, general loss of efficiency, in fact, general chaos.

And this quite apart and distinct from the terrible moral loss resulting from accidents and the suffering endured both by the individual man who is injured, and by his family; the impairment of the individual's working ability and his efficiency; the maiming of men; in fact, no matter how one looks at the situation, one must be convinced of the fact that the safety campaign has been productive of well nigh incalculable good for everybody, for the man, for his family, for the general well-being and efficiency of the plant and for the corporation.

Further Proof of Decrease.

Another interesting feature of the accident situation is the classification as to nature of injuries received and the percentage of lost-time attributable to these various injuries.

Taking the campaign months—October, November, December, 1920, and January, February, March and April, 1921, as a basis and comparing them with the same seven months of 1919 and 1920—that is to say, October, November, December, 1919, and January, February, March and April, 1920, one finds that in the last mentioned period there were 316 accidents with 6,396 days of lost time as a direct result of said accidents. For the same period of time covered by the campaign, that is to say, from October 1, 1920, to May 1, 1921, there were 155 accidents entailing a loss of time of 1,789 days.

In these figures, distributing the accidents as to their nature, one again finds evidence of the decrease in severity. For instance, there is a falling off in the number of fractures, the number of infections, and, especially, in the number of miscellaneous injuries, notably foreign bodies in eyes. This is directly attributable to the eductional work which we have been carrying on.

The percentage of accidents under the various classifications and the percentage of lost-time caused by said accidents for the two periods were as follows:

October 1, 1919, to May 1, 1920: Total of accidents, 316. Total time lost, 6,396 days.

	Percentage of Accidents	Percentage of Time Lost
Contusions	38.5	33.1
Lacerations	26.6	25.7
Burns	13.2	10.4
Sprains	8.2	5.9
Infections	3.4	4.9
Fractures	6.7	17.8
Miscellaneous (such as foreign bodies in eyes, asphyxiation, ruptures, etc.)	3.4	2.2

October 1, 1920, to May 1, 1921: Total of accidents, 155. Total time lost, 1,789 days.

	Percentage of Accidents	Percentage of Time Lost
Contusions	36.7	36.4
Lacerations	25.8	22.2
Burns	19.1	13.7
Sprains	10.2	8.6
Infections	2.3	2.7
Fractures	4.4	15.7
Miscellaneous (such as foreign bodies in eyes, asphyxiation, ruptures, etc.)	1.5	1.0

Steel Company Completes Improvements

The Electric Alloy Steel Company Expend Nearly a Million Dollars in Improvements and Additions at Their Charleroi, Pa., Plant — Will Manufacture Alloy and High Grade Tool Steels.

By DONALD N. WATKINS.

IT is an unquestioned fact that insofar as quantity production of steel is concerned, America is preeminent. However, varying from the general condition in America and feeling that equally as good steel could be made here as anywhere else on earth, if the question of quantity was forgotten and quality was placed foremost, a representative group of men, who, in their individual capacities, are actively associated with the production of over one-half of the total steel made in America, organized the Electric Alloy Steel Company, Youngstown, Ohio, for the purpose of carrying out their conviction.

The following men were the organizers and are the active directors: A. E. Adams, president of the First National & Dollar Banks of Youngstown; T. J. Bray, president of the Republic Iron & Steel Company; L. J. Campbell, formerly vice president of the Youngstown Sheet & Tube Co.; Maurice Joseph, president of the Joseph Joseph & Bros. Co.; Severn P. Ker, president of the Sharon Steel Hoop Company; L. A. Manchester, general counsel for the Youngstown Sheet & Tube Company; S. Livingstone Mather, secretary of the Cleveland Cliffs Iron Company; Chas. S. Thomas, formerly president of the De Forrest Sheet & Tin Plate Company; W. A. Thomas, formerly president of the Brier Hill Steel Company, and Jonathan Warner, president of the Trumbull Steel Company. These men met in Youngstown, January, 1920, and selected the following officers: L. J. Campbell, president; A. E Adams, vice president; W. D. Myres, secretary-treasurer, and Gustaf Peterson was appointed general manager of sales. Later a plan was formulated to take over the plant of the Universal Steel Company at Charleroi, Pa., and rebuild it to suit the manufacture of high-grade steel. This plant was actively taken over June, 1920, and in August of the same year the rebuilding plans were put under way. Barton R. Shover was secured as consulting engineer and under his direction and that of G. W. Knight, chief engineer of the company, such equipment was installed as would assure from the beginning the very highest quality of steel.

To begin with, the new plant is ideally situated for the manufacture of steel. It is located on a 12-acre tract bordering on the Monongahela River about 40 miles above Pittsburgh. The property also has connection with both the Pennsylvania and P. & L. E. Railroads. The land is underlaid with a $6\frac{1}{2}$-foot vein of river coal. Gas wells are also being drilled upon the property in the expectation that the company may be able to secure a flow of this fuel from their own land.

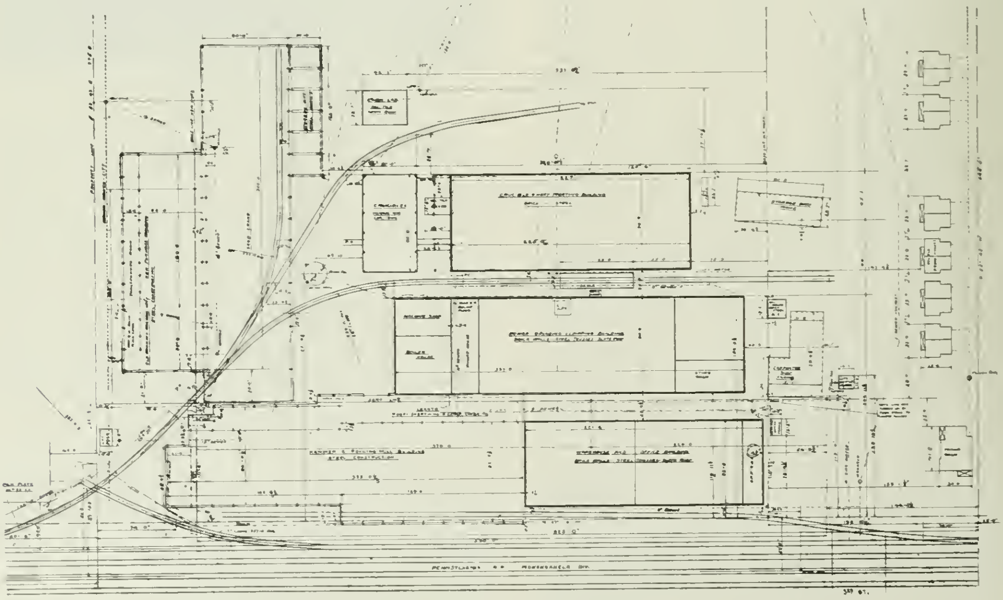

Fig. 1—General plant layout.

Stock Yards.

The raw materials which consist principally of clean, low phosphorous and sulphur scrap, Swedish muck bar, and imported and domestic ferro alloys are received by rail in the 330-foot x 80-foot building which covers the stock yard. This building is equipped with a 10-ton overhead crane made by the Alliance Machine Company. Electric Controller and Manufacturing magnets are used in picking up the raw materials. In addition to this, there are storage bins which cover 120 feet x 30 feet.

Steel Producing Facilities.

Steel is manufactured by two processes, the electric furnace process and the crucible process. The electric furnace building, which is 200 feet x 75 feet, contains 1 Heroult 6-ton electric furnace. A second 6-ton electric furnace of the same type, with all the latest Westinghouse equipment, is being installed. Housing facilities have been provided and foundations have been set for a total of four 6-ton electric furnaces, all of which will eventually be installed in this building.

The electric furnace building is equipped with two 15-ton overhead electric cranes. One was made by the Alliance Machinery Company and the other by the Whiting Corporation. The steel is poured from the electric furnace into Gathmann moulds of special design through a pouring buggy especially designed for box pouring. Ingots are made of sufficient size to allow proper working and grain refinement in finishing department. Included in the equipment of the electric furnace building are annealing and cooling pits. These pits are used in order that the steel may be cooled slowly to remove any internal stresses. The ingots are hauled from these pits to the rolling mills or stock yards on ingot buggies by a Westinghouse Baldwin Electric Locomotive.

The rolling mill department contains a 10-inch and a 16-inch mill. These mills are the latest design, and were made by the A. Garrison Foundry Company. The 16-inch bar mill is equipped for rolling rounds in tool and alloy steel up to 4-inch diameter. It is also equipped to roll squares and flats up to the same area. The 10-inch mill is equipped for rolling tool and alloy steels of various sizes and shapes. All rolls used in these mills are designed and turned at the plant. The mills are driven by a Garrison Foundry & Machine Co. steam engine. Feeding these two mills are two coal-fired heating furnaces of special design.

The cooling bed and shearing capacity will easily take care of the output of the mill.

Crucible Department.

The crucible department consists of one building 90 feet x 60 feet and an additional equal space in another building, 225 feet x 90 feet. Each of these buildings contains a 24-pot crucible furnace. Utmost care is taken, particularly in the material used in the production of high-speed steels, which are made in these buildings. All steel is poured from the pots into a 3-ton Whiting ladle and then into the ingot moulds. From here the steel is delivered to the hammer shop and mills.

Hammer Shop.

The hammer shop equipment includes the following series of hammers: one 650-pound Chambersburg tilt hammer, and 1,000, 2,000, 3,500 and 8,000-pound Chambersburg steam hammers. There are four forced-draft coal-fired heating furnaces of special design with under-hearth flues used. There is also one double furnace of similar design and one small gas-fired furnace for tilt hammer use, exclusively. These furnaces were all designed and built by the plant organization. The hammer shop is to be equipped with a 5-ton overhead traveling crane.

Sound, clean surfaces on the finished product are assured by extensive grinding and chipping capacity. Twelve new grinders of the latest improved swing frame type, individually motor driven, have just been installed. These grinders were made by the Springfield Manufacturing Company. Ample chipping capacity has been provided. Thor chipping hammers are generally used throughout the plant.

Annealing Department.

The annealing department is equipped to take care of bars up to 25 feet in length. This department's equipment consists of a series of furnaces, the principal one of which is a large car type annealing furnace. There are also a number of furnaces, some gas and some electric heated, which were designed and built by the plant organization. Uniformity of temperature in annealing is assured by control with multiple point recording pyrometers of the latest Leeds & Northrup and Wilson & Maeulen types. Hardening equipment takes care of the high-speed tool bits and of alloy and tool steels in bars up to 6 feet in length. This equipment consists of a lead vat, vertical quenching tanks and oil and salt drawing vats.

Inspection Department.

All processes in the mill are under regular chemical and metallurgical supervision. All scrap and raw materials which enter into the composition of the steel are without exception carefully sampled and analyzed on their receipt to insure uniformity of product. The large chemical laboratory which consists of a room devoted solely to preliminary and final analyses and a general laboratory for the crucible steels, raw materials and special analyses are part of the equipment of the plant. In addition there is a sampling room containing drill presses, a crusher, milling machines, air hammers and other sampling equipment. There are also special rooms for carbon determinations, sulphur determinations, electrolytci equipment and a balance room. A telautograph is to be provided to report analyses to the electric furnace department.

During the course of manufacture the purity of the steel is constantly watched by inspection under the microscope. Soundness of the steel and uniformity of heat treatment are further checked by the use of a binocular microscope.

The equipment for mechanical tests consists first of a 100,000-pound tensile testing machine, a Swedish Brinell machine, scleroscope and portable Brinell meter. New equipment just built at the plant includes an impact testing machine similar to the Charpy type, and a repeated stress testing machine is to be installed. For investigation of new steels and their heat treatments a critical point apparatus is being installed, consisting of a Rosenhain furnace used in conjunction with a new type of portable precision potentiometer. The latter instrument is of new design by the Leeds & Northrup Co. It is also to be used in checking pyrometers against Bureau of Standards calibrated couples.

Power.

The steam power for the plant is generated in a very modernly equipped boiler house. This boiler house contains two 333-hp Wickes vertical boilers equipped with Murphy automatic stokers and draft regulators. Other equipment included are Wilson-Snyder pumps, a Copes feed water regulator and Berry ari compressors. Exhaust steam is used for preheating feed water. A new coal conveyor is now under consideration.

The water used in the plant is pumped from the Monongahela River by a Triplex pump to a large water tower. This tower serves the plant, mills and furnaces in general.

Some electric equipment of the very latest Westinghouse type has recently been installed. Electric power for operating the plant is purchased from the West Penn Power Company. Their lines enter into an outdoor switching station at 22,000 volts, 3 phase, 60 cycles. At this point the lines are protected by electrolytic lightning arresters. From the main switch, current is carried to a 22,000-volt buss in the transformer room, to which three banks of transformers are connected through proper switching. The total load is about 4,000 kva. Two banks of transformers supply the two electric furnaces. The voltage on the furnace is 110, and each furnace consumes about 8,000 amperes per phase. The power transformers reduce the 22,000 volts to 2,200, which is carried from the transformer room to the sub-station. Here it is distributed to the various parts of the plant. In the sub-station is located the motor generator set which furnished direct current for the cranes, etc. A 1,300-cubic-foot-per-minute Chicago pneumatic air compressor is installed. This furnishes compressed air for the entire plant. There are also two small air compressors which are used in emergencies. In the sub-station one bank of transformers reduces the 2,200 volts to 220 volts for the operation of small motors. All high voltage lines and equipment throughout the plant are protected by screens, etc., to insure the safety of employees. The transformers were furnished by the Pittsburgh Transformer Company and the Westinghouse Electric & Manufacturing Co. The control apparatus for the cranes was made by the Cutler Hammer Manufacturing Company. Other electrical equipment was furnished by the General Electric, Cutler Hammer and Westinghouse Elec. & Mfg. Companies.

For weighing outgoing and incoming materails a new Fairbanks 300,000-pound capactiy railroad scale has been installed. There are numerous other Fairbanks scales throughout the plant for weighing the ingots, scrap and other materials which are transported on narrow gauge tracks.

The office building contains accommodatoins for the entire office personnel, engineering department and purchasing department.

A number of very well-known operating officials have been placed in charge of the plant. The general superintendent is Geo. W. Morrison, formerly rolling mill superintendent, Carbon Steel Company, Pittsburgh; assistant general superintendent, in charge of steel making, L. B. Knox, formerly assistant works manager with the Sizer Forge Company, Buffalo; metallurgist, Marcus A. Grossman, formerly with the United States Bureau of Standards, Washington, D. C.; chief engineer, G. W. Knight, formerly with the Westinghouse Electric Company and Midvale Steel Company.

REFRACTORIES FOR ELECTRIC FURNACES

R. M. Howe recently published an article in "Chemical and Metallurgical Engineering," describing the refractories available for use in electric furnace work, with some notes on their origin, details of the more important properties, the factors affecting their suitability for various duties, the best methods of utilizing them and precautions to be taken to obtain a satisfactory life. Various refractories not yet in commercial supply are also considered and their probable spheres of usefulness indicated.

The nine raw materials which enter into consideration are, fireclay, silica (ganister), magnesite, dolomite, chromite, bauxite, zirconite, carborundum and alundum. Typical compositions are quoted, together with the melting points. Various refractories, however ,break down at temperatures below their melting point when subject to pressure and the relative figures are quoted for a number of samples. The specific gravity and electrical resistivity are given and the influence of temperature on the latter property indicated, all the materials showing a decidedly decreased resistivity with rising temperature. Specific heats and thermal conductivities are given where figures are available. The resistance of the refractories to temperature changes are classified, fireclay being much less ssuceptible than silica, magnesite and chromite.

Heat insulation of the refractories is to be avoided, and it is considered that water cooling of the outer surfaces would be a decided advantage in many instances. The satisfactory service given by silica bricks in furnace roofs is thought to be due to their high termal conductivity and the fact that they remain rigid under pressure at high temperatures. Zirconia bricks are thought likely to solve many problems in furnace work when the commercial disadvantages in connection with their manufacture are ovrcome. For this it is essential that the raw material shonld be pure and it must be bonded into a mechanically strong brick which should undergo little shrinkage after being installed. Bauxite bricks are somewhat similar to zirconia. Carborundum and alundum bricks offer the same advantages as silica, but in addition are not likely to disintegrate so readily under fluctuating temperatures.

All bricks should be protected from rain during storage, laid with a cement composed of material similar to the bricks or one which will not corrode them and with as thin a joint as possible. The furnace should be constructed so that heat will readily be radiated from the hottest portions and the ratio of heating to cooling surfaces should be as low as possible. Refractories should be heated from one side only and insulation should be avoided even to the extent of preventing the accumulation of dust on the roof. When the furnace is being heated up this should be done very gradually, especially where magnesite or silica bricks are involved and when the furnace is being cooled, cold blasts should be avoided as these greatly accelerate disintegration of the refractories.

Common Electric Generator Troubles

How to Overcome Difficulties Arising In Generator Sets in the Shortest Possible Time — Delays Due to Such Trouble a Serious Factor In Steel Mill Production.

By F. A. SWEET.

WHEN a generator fails to produce current the cause can usually be traced to the inability of a self-excited unit to build up its field. To start such a unit properly a certain amount of field residual magnetism is required, which must be increased to full strength by the current generated in the machine itself. This trouble is not likely to occur in a separately excited unit, and if it does it is usually due to the failure of the exciter.

The cause of this condition is weak or destroyed residual magnetism, due to vibration or jar, proximity of another current, a strong current through the armature when there is little or no field current, which tends to neutralize or reverse the field owing to the reverse ampere turns, and accidentally reversed current through shunt or series field coils, which may not be enough to reverse the magnetism completely. Reversal of magnetism will not cause failure to generate. The symptom of this ailment is weak or no attraction when the pole pieces are touched with a piece of iron.

To relieve the condition, send a magnetizing current from another machine through the field coils, then start the generator again. If this fails, change the direction of the exciting current, since it may have enough polarity to prevent them building up in the case. Shifting the brushes backward will make the armature magnetism assist that of the field. Change the polarity of the machine so that influence of adjacent machines will have opposite effect.

Another cause to be reckoned with is reversed connections, or reversed rotation. An indication of this condition is the fact that while running the pole pieces will not attract a piece of iron. The application of external excitation will not, in this case, make the machine generate, because whatever field is built up is destroyed by the armature current.

The remedy is to reverse either the field or armature connections, to move the brushes through 180 degrees for two-pole, 90 degrees for four-pole, 60 degrees for six-pole, etc., or to reverse the direction of rotation. After any of the above alterations the field will have to be excited from an outside source.

Another cause is short-circuiting of either the internal or external circuit, which manifests itself in weak magnetism: If the short is in the external circuit it will prevent a shunt dynamo from building its field; but with a series machine, the building up of the field will be hastened. If the short is in the machine it will likely prevent the building up of either type. A slight short such as a defective socket or copper dust on the commutator may prevent a shunt machine from building up, as will also an overload.

Field coils opposed to each other are still another cause of failure to generate. The evidence of this condition is the appearance, when tested with a compass, of similar poles adjacent to each other. This state of affairs can be corrected by reversing the connections on the reversed poles.

An open circuit, which may be caused by a broken wire or faulty connection in machine, brushes not in contact, safety fuse being blown or circuit breaker being out, or an open switch will naturally cause failure to generate.

If the trouble is an external open circuit, the field of a shunt machine will be fully magnetized and the machine will be working perfectly; but if the trouble is inside the machine, the fields will be weak. A break in the field circuit of a separately excited installation will prevent generation, and is indicated by no field in the generator and full exciter field.

A break in a single-phase series-wound armature will result in non-generation; in a two-or-three-phase Y-armature will cause it to generate single-phase; while in a delta armature it continues to give three-phase, but at reduced capacity.

To remedy, make a careful inspection for open circuit in both field coils and armature. A break or excessive resistance in the shunt field or field regulator will also make the magnetism weak. This may be detected by cutting out the rheostat for an instant or by connecting the two terminals of the field coils to the brushes in first one and then the other direction.

A high resistance in the circuit of a series-wound machine will prevent building up. Short the machine momentarily to start the field.

Failure to generate may also be caused by the brushes being improperly placed. The tell-tale of this condition is a change in the magnetism and voltage when the brushes are shifted.

It frequently happens that the brushes are not set at the correct point or they may be set at exactly the wrong position, in which case the machine is incapable of delivering any current whatever. This trouble is probably due to the fact that no two machines have the same setting. Drawings should be obtained showing the proper position of the brushes before an attempt is made to set them.

Sparking at the commutator is a common trouble. One cause of this is excessive armature current, due to an overload on the machine, short circuit, ground, or excessively high voltage.

To remedy, reduce the load, eliminate the short circuit or ground, or reduce the voltage.

Brushes not set at the neutral point may cause excessive sparking. In this case the sparking will vary when the brushes are shifted. The brushes should be shifted until the trouble disappears. Care should be taken to see that the brushes are exactly opposite.

A commutator rough, eccentric or with high bars will cause sparking, due to imperfect contact of the brushes. A rough commutator should be filed or stoned down, or even taken out and turned if extremely bad. Eccentricity may be in the armature or merely due to a loose bearing. If the former, it should be turned down; if the latter, new bearings should be fitted.

In order that the commutator should wear smooth, the shaft should be allowed end-play of about one-eighth inch.

Other causes of poor conductivity at the brushes are dirty or oily brushes, a glass-hard brush which is incapable of wearing to a good seat, or a brush that has a specific resistance.

The remedy is to clear the fouled parts and replace poor brushes.

A short-circuited or reversed coil in the armature will cause sparking, which condition can be noticed by the excessive power required to run the generator without load. The short-circuited coil heats faster than the others and is likely to burn out unless promptly attended to. A piece of steel held between the pole pieces near the armature will vibrate as the defective coil passes.

Such a short is often caused by a piece of solder or other metal getting in between the commutator bars or their connections. The trouble is easily found and remedied. If, however, the short is in the coil itself the only reliable repair is to rewind the coil.

A broken armature circuit will cause violent flashing and the bar nearest the break will be badly burned. A poor contact somewhere in the cicuit will have this same effect to a lesser degree.

Such a break or poor contact may be located by the drop of potential or continuity test. The break is usually in the connections between the coil and bar, where it can be readily repaired. If it is in the coil the only remedy is to rewind the troublesome part.

A ground in the armature will often cause sparking. When two or more grounds occur in the armature the result is a short circuit, and the case should be so treated. A single ground on electric railway-line or a three-wire system with the neutral wire grounded will have the same effect.

To find the ground, wrap a flexible conductor around the commutator. Apply a current through this will flow and the defective coil will be energized. It can then be located with a compass.

A wea kmagnetic field causes sparking. The telltale of this condition is weak pole pieces, and the point of least sparking is shifted considerably from the normal position. Full voltage or current is not forthcoming.

The causes of this condition are: 1. A broken circuit, which may be found by opening the field circuit after having insulated the field: if no spark occurs there is a break some place in the circuit. 2. Short circuit. 3. Grounding, which may be found by drop-in-potential method.

A broken circuit is easily repaired if accessible; if it is in the coil the coil will have to be rewound. If the circuit voltage is low, sparking will result. If it cannot be raised the field resistance should be reduced by unwinding a few layers of wire.

Flashing over is a spark jumping from one set of of brush-holders to another or to the frame. This is caused by poor or insufficient insulation between the points mentioned, or by deposits of copper or carbon dust on the surface of the insulation. This latter is the usual cause, and the trouble can be eliminated by simply cleaning the parts with an oily cloth

Ring fire is an exaggerated case of commutator sparking and may cause flashing from one set of brushes to the next. The remedies for commutator sparking will obviously do away with this trouble.

Any of the causes of sparking will cause heating of the commutator. In fact, heating frequently occurs from these causes before sparking is noticeable.

The next in importance is heat spreading from other parts of the machine. The machine should be started when cool and run for a few minutes, then a search made for warm parts before the heat has a chance to radiate to the rest of the machine.

These parts should be attended to as directed under their respective headings.

An overhead commutator will cause deterioration of the brushes and cover it with a black film, which offers more resistance and aggravates the trouble. The commutator should be cleaned and the different brushes fitted if necessary.

Brush connections may offer abnormally high resistance, which may be tested by the drop of potential method and improved.

Heating will occur when there is an arc or short circuit between bars or between bars and end ring. The arc will be noticeable when the machine is running. Burnt or otherwise defective insulation should be taken out and replaced.

Brushes of high specific resistance will produce heat. Better carbons or greater conductivity should be installed .

The friction of the brushes will also produce heat. This case can be differentiated from the preceding one by noting whether or not the temperature is excessive when the current is light. This may be due to heavy pressure or high speed. Reduce the spring tension. Decrease speed, but keep up the voltage by increasing the field. Lubricate slightly with oil or vaseline.

Excessive current will cause heating of the armature, as will also moisture in the coils. Moisture can be detected by steaming when hot. The armature should be taken out and baked for several hours at a temperature sufficiently high to drive out the moisture, but not hot enough to injure the insulation.

When the iron of the armature core is found to be warmer than the coils after a short run, and when considerable power is required to turn the armature when there is no current through it, and when the field is connected, indications are that there are eddy currents in the core. There is a question of poor laminatoin and a matter of primary construction.

Reversed coils in one part of an armature will cause local currents to circulate around a direct-current armature, causing a rise in temperature. This will mean excessive power to drive a generator without load. A compass will indicate the reversed coil when a current is sent through each coil separately The remedy lies in simply reconnecting the terminals to agree with the rest.

Excessive current in the field circuit will bring about heating of the field magnets. A temperature of 1220 degrees F. above room, as determined by a resistance test, is considered high.

In the case of a shunt-wound or separately excited machine, decrease the field voltage or increase the resistance. In the case of series winding, shunt a portion of the current. This condition might be caused by a short circuit, in which case the defective coil will be cooler than the others. As a check, measure the resistance of each coil; if there is any considerable variation, the low resistance coil is sure to be grounded or short-circuited.

In alternating or pulsating current work the field pieces will become heated, due to eddy currents, unless they are carefully laminated.

Moisture in these coils will cause short-circuiting and heating, as in the armature.

Heating of bearings is a condition to which any machine not properly constructed or attended to is subject. In cases where a stop for repairs would be fatal, temporary relief may be had by pouring cold water on the bearing or packing it in ice.

This state of affairs is usually due to lack of oil. The oil passages may be clogged, the reservoir dry, the oiling devices out of order. These defects should, of course, be remedied. Use good oil; it will be money well invested.

Grit in the bearings will cause heating. Remove the bearing and investigate for foreign particles. Scratches will be noticed. Remove the dirt, clean the bearing, use clean oil, and provide a dirt-proof casing if necessary.

A shaft that is rough, scored, or too large will also cause heating. It should be turned down in a lathe and refitted.

A sprung shaft presents difficulties in truing, and a new one is usually necessary.

A shaft turns hard and heats when the bearings are out of line. Conditions are relieved by loosening the holding bolts. Bolt the bearings in a position where the shaft turns freely, being sure that the armature is in the center of the field.

Thrust of a shoulder or the shaft against the bearings will generate heat, and is caused by the belt drive being out of line or by the armature not being centered axially with the field coils. The remedy will be found in lining up the belt or moving the collar to allow the shaft to center itself.

Too heavy tension on the belt or eccentricity of the armature will cause an extra load on one side of the bearing and heating of the bearing, which will wear elliptical in time and aggravate the trouble due to an eccentric armature. The belt tension should be decreased, using a larger pulley if necessary, and the armature should be centered. If the bearings have worn elliptical, new ones should be fitted.

The most frequent source of noise is the humming, speaking, or hissing of the brushes on the commutator. This trouble can readily be located by the ear. File or dress the brushes down with sandpaper and apply a little oil or vaseline. Changing the length of the brushes and the pressure often helps.

Vibration due to the revolving armature, field, pulley, or commutator being out of balance is, of course, objectionable. The parts should be taken out and balanced, separately, because a static balance of the whole combination is not likely to prove to be a dynamic one. A dynamic balance takes place only when equal moments are directly opposed to each other.

When the armature rubs against the pole pieces noise results. Bind down any abnormal projection on the armature; center the armature; chip off high spots on the field pieces.

Noise caused by the collar or pulley rubbing on the bearing is due to the same condition that causes bearings to heat, and should be so treated.

Rattling due to the looseness of parts can be eliminated by careful inspection of the machine before or after each run. Tighten up the loose parts. Replace a poorly fitting bearing.

The flapping of a belt joint on the pulley produces a disagreeable sound which should be stopped by making a better joint.

An intermittent squeaking sound which indicates a slipping belt, may be overcome by increasing the tension of the belt or by applying a belt dressing.

The humming of the armature core teeth as they pass the pole pieces ought not to occur if the machine is properly constructed. It can be relieved by sloping the edges of the pole pieces.

Humming due to alternating current is inherent to a large extent in alternators, but can be deadened by mounting the machines on felt or some such material.

Improper voltage is a common difficulty which may arise in any machine, and is due to the following causes: Field magnetism too strong or too weak; brushes not in proper position; generator overloaded; short-circuited or reversed armature coils.

All of these produce sparking and are dealt with under that head.

Speed too high or too low, or open short-circuited or reversed field coils may prevent a dynamo from generating curent.

A direct or alternating-current generator, unless it is compound or composite, would tend to fall in voltage with increased load. This is usually overcome by raising the field current or by cutting out field resistance.—"Power House."

SHATTERED ZONES IN STEEL RAILS

J. E. Howard recently read a paper before the American Society for Testing Materials which deals with methods whereby interior shattred zones in steel rails may be located and examined; inferentially leading to the conclusion that shattered zones represent thermal effects, shrinkage cracks. In rails they are located along the middle of the head, and at the junction of the web and base; the period in which they form is conjecturally held to be at the time of cooling after the last pass of the rail mill. The shattered zones thus far examined have been confined to hard or medium hard steels.

In respect to the association of transverse fissures with shattered rails, transverse fissures have been found in rails both with and without shattered heads; and shattered heads have been found without transverse fissures. Thus it appears that a shattered state of the metal is not a necessary precursor to the formation of a transverse fissure.

The paper refers to a physical law explaining why the fissure has an internal origin, based upon the internal strains acquired by the rails in service. Attention is called to the distinction between causes which tend toward the rupture of all rails and the ultimate resistance of different stels whereby some rails resist certain wheel loads while others do not.

Rails are not regarded as permanent members in engineering structures by reason of the cold-rolling action of the wheels, which strains the zone of metal next to the top of the head beyond its elastic limit.

Proposed Revised Specifications for Steel Products

Abstract of Report Made by Committee at the Twenty-fourth Annual Meeting of the American Society for Testing Materials, Asbury Park, N. J., June 21-24, 1921.

Proposed Revised Specifications for Welded and Seamless Steel Pipe.*

THESE specifications cover "standard" and "extra strong" welded and seamless steel pipe, but not "double extra strong" pipe. Pipe ordered under these specifications are intended for bending, flanging and other special purposes.

I. MANUFACTURE.

2. (a) The steel for welded pipe shall be of soft weldable quality made by the Bessemer or open-hearth process. The steel for seamless pipe shall be made by the open-hearth process.

(b) Welded pipe 3 inches or under, in nominal diameter, may be butt-welded, unless otherwise specified. Welded pipe over 3 inches, in nominal diameter, shall be lap-welded.

II. CHEMICAL PROPERTIES AND TESTS.

3. Open-hearth steel shall conform to the following requirement as to chemical composition:

Phosphorus..........not over 0.05 per cent.

This abstract of the report of the Committee on Steel, furnished to the American Society for Testing Materials, is published herewith because it will effect a majority of the steel producers. It is not possible for all of our readers to either attend the meeting of this society or obtain a copy of the report of this particular committee, and feeling that possibly some of our readers may have criticisms or suggestions to make on these specifications, which may be of real benefit, we have taken this means of presenting the same to them.

III. PHYSICAL PROPERTIES AND TESTS.

4. (a) The material shall conform to the following minimum requirements as to tensile properties:

	Welded		Seamless
	Bessemer	Open-Hearth	Open-Hearth
Tensile strength, lb., per sq. in..	50,000	45,000	48,000
Yield point, lb. per sq. in.......	30,000	25,000	26,500
Elongation in 8 in., per cent....	18	20	18

(b) The yield point shall be determined by the drop of the beam of the testing machine.

5. (a) Welded pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

(b) Seamless pipe shall be tested at the mill to hydrostatic pressures not exceeding that required by the formula:

$$P = \frac{2St}{D}$$

in which P = pressure in pounds per square inch; S = allowable fiber stress = 16,000 pounds per square inch; t = thickness of wall in inches; and D = inside diameter in inches.

6. (a) For lap-welded pipe over 2 inches in diameter, a section of pipe 6 inches long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 degrees from the line of direction of the applied force, without developing cracks.

(b) For butt-welded pipe over 2 inches in diameter, a section of pipe 6 inches long shall be flattened between parallel plates until the distance between the plates is 60 per cent of the outside diameter of the pipe with the weld located 45 degrees from the line of direction of the applied force, without developing cracks.

7. For pipe 2 inches or under in diameter, a sufficient length of pipe shall withstand being bent cold through 90 degrees around a cylindrical mandrel, the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

8. (a) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(b) Tension test specimens shall be longitudinal.

(c) All specimens shall be tested cold.

9. One of each of the tests specified in Sections 4, 6 and 7 may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

10. If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

11. (a) The standard weights for pipe of various inside diameters are given in Table II.

(b) Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

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*Criticism of these tentative specifications are solicited and should be directed, preferably before January 1, 1922, to Mr. F. M. Waring, chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

These specifications, when adopted as standard, will supersede the present standard specifications for welded steel pipe (serial designation: A 53-18), 1918 Book of A. S. T. M. standards.

Table I—Hydrostatic Pressures for Welded Steel Pipe.

(Pressures expressed in pounds per square inch.)
(Black and Galvanized)

Size (Nominal Inside Diameter), Inches	"Standard" Pipe			"Extra Strong" Pipe		
	Weight of Pipe per Linear Foot, Threaded and With Couplings, Pounds	Butt-Weld	Lap-Weld	Weight of Pipe per Linear Foot, Plain Ends, Pounds	Butt-Weld	Lap-Weld
⅛	....	700	....	....	700	....
¼	....	700	....	....	700	....
⅜	....	700	....	....	700	....
½	....	700	....	....	700	....
¾	....	700	....	....	700	...
1	....	700	....	....	700	....
1¼	....	700	1000	....	1500	2500
1½	....	700	1000	....	1500	2500
2	....	700	1000	....	1500	2500
2½	....	800	1000	....	1500	2000
3	....	800	1000	....	1500	2000
3½	....	....	1000	....	....	2000
4	....	....	1000	....	....	2000
4½	....	....	1000	....	....	1800
5	....	....	1000	....	....	1800
6	....	....	1000	....	....	1800
7	....	....	1000	....	....	1500
8	25.00	....	800	....	....	....
8	28.81	....	1000	43.39	....	1500
9	34.19	....	900	48.73	....	1200
10	32.00	....	600	....	....	....
10	35.00	....	700	....	....	....
10	41.13	....	900	54.74	....	1000
11	46.25	....	800	60.08	....	1000
12	45.00	....	600	....	....	....
12	50.71	....	800	65.42	....	1000

For pipes over 12 inches in inside diameter, the test pressure should be calculated by the formula $P = \frac{2\,St}{D}$ in which P = pressure in pounds per square inch; S = fiber stress = 12,000 pounds per square inch; t = thickness of wall in inches; D = inside diameter in inches.

12. The weight of the pipe shall not vary more than 5 per cent from that specified in Table II.

13. Unless otherwise specified, pipe shall be furnished as to lengths in accordance with the following regular practice:

Table II—Standard Weights and Dimensions of Welded and Seamless Steel Pipe.

(Black and Galvanized)

Size (Nominal Inside Diameter), Inches	"Standard" Pipe				"Extra Strong" Pipe	
	Outside Diameter, Inches	Number of Threads Per Inch	Thickness Inches	Weight of Pipe Per Linear Foot, Threaded and With Couplings, Pounds	Thickness, Inches	Weight of Pipe Per Linear Foot, Plain Ends, Pounds
⅛	0.405	27	0.068	0.25	0.095	0.31
¼	0.540	18	0.088	0.43	0.119	0.54
⅜	0.675	18	0.091	0.57	0.126	0.74
½	0.840	14	0.109	0.85	0.147	1.09
¾	1.050	14	0.113	1.13	0.154	1.47
1	1.315	11½	0.133	1.68	0.179	2.17
1¼	1.660	11½	0.140	2.28	0.191	3.00
1½	1.900	11½	0.145	2.73	0.200	3.63
2	2.375	11½	0.154	3.68	0.218	5.02
2½	2.875	8	0.203	5.82	0.276	7.66
3	3.500	8	0.216	7.62	0.300	10.25
3½	4.000	8	0.226	9.20	0.318	12.51
4	4.500	8	0.237	10.89	0.337	14.98
4½	5.000	8	0.247	12.64	0.355	17.61
5	5.563	8	0.258	14.81	0.375	20.78
6	6.625	8	0.280	19.19	0.432	28.57
7	7.625	8	0.301	23.77	0.500	38.05
*8	8.625	8	0.277	25.00	....	....
8	8.625	8	0.322	28.81	0.500	43.39
9	9.625	8	0.342	34.19	0.500	48.73
*10	10.750	8	0.279	32.00	....	....
*10	10.750	8	0.307	35.00	....	....
10	10.750	8	0.365	41.13	0.500	54.74
11	11.750	8	0.375	46.25	0.500	60.08
*12	12.750	8	0.330	45.00	....	....
12	12.750	8	0.375	50.71	0.500	65.42

*Unless specifically stated on the order the lighter weights will not be furnished. Weights given in the table are for pipes up to and including 12 inches in nominal inside diameter, with threaded ends and couplings; sizes larger than those shown in the table are measured by the outside diameter and will be furnished with plain ends unless otherwise specified; for such sizes it will be necessary to accept manufacturers' weights or calculate the weights on the basis of one cubic inch of steel weighing 0.2833 pounds.

(a) Standard pipe shall be in random lengths of 16 to 22 feet, but not more than 5 per cent of the total number of lengths may be "jointers," which are two pieces coupled together. When ordered with plain ends, 5 per cent may be in lengths of 12 to 16 feet.

(b) Extra strong pipe shall be in random lengths of 12 to 22 feet. Five per cent may be in lengths of 6 to 12 feet.

V. WORKMANSHIP AND FINISH.

14. For pipe 1½ inches or under in inside diameter, the outside diameter at any point shall not vary more than 1/64 inch over nor more than 1/32 inch under the standard size. For pipe 2 inches or over in inside diameter, the outside diameter shall not vary more than 1 per cent over or under the standard size.

15. Unless otherwise specified, pipe shall conform to the following regular practice:

(a) Each end of standard welded pipe shall be threaded.

(b) Extra strong welded pipe and standard and extra strong seamless pipe shall be furnished with plain ends.

(c) All threads shall be in accordance with the American Standard* and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gauge, shall not exceed a maximum of one and one-half turns either way.

(d) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be made of wrought iron or steel.

16. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

VI. INSPECTON AND REJECTION.

17. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipe are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

18. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

Proposed Tentative Specifications for Carbon-Steel Rails.†

I. MANUFACTURE.

1. The steel shall be made by the Bessemer or open-hearth process as specified by the purchaser. The entire process of manufacture shall be in accordance with the best current practice.

2. There shall be sheared from the end of the bloom, formed from the top of the ingot, sufficient metal to secure sound rails.

3. The addition of aluminum to the molds shall not be permitted.

II. CHEMICAL PROPERTIES AND TESTS.

4. The steel shall conform to the following requirements as to chemical composition:

Elements Considered.	70-84 lb. per yd. Inclusive	85-110 lb. per yd. Inclusive
Bessemer Steel.		
Carbon, per cent.........	0.40 to 0.50	0.45 to 0.55
Manganese, per cent......	0.80 to 1.10	0.80 to 1.10
Phosphorus, max. per cent.	0.10	0.10
Silicon, min. per cent.....	0.10	0.10
Open-Hearth Steel.		
Carbon, per cent.........	0.53 to 0.68	0.62 to 0.77
Manganese, per cent......	0.60 to 0.90	0.60 to 0.90
Phosphorus, max. per cent.	0.04	0.04
Silicon, min. per cent.....	0.10	0.10

5. It is desired that the percentage of carbon in an entire order of rails shall average as high as the mean percentage between the upper and lower limits specified.

6. (a) To determine whether the material conforms to the requirements specified in Section 4, analyses shall be made as follows:

(b) For the Bessemer process analyses shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, sulphur and silicon. These analyses shall be made from drillings taken at least 1/8 inch beneath the surface of a test ingot obtained during the pouring of the melt. The carbon content shall be reported for each melt, and two averages of the percentages of carbon, manganese, phosphorus,sulphur and silicon shall be reported to the inspector daily, one for each day and night turn, respectively.

(c) For the open-hearth process an analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, sulphur and silicon. This analysis shall be made from drillings taken longitudinally of the rail, using a ½-inch drill, close to an upper corner of the head from any one of the three drop-test pieces representing the top of the ingot or from pieces cut adjacent to any one of these three drop-test pieces. The chemical composition thus determined shall be reported to the inspector.

7. (a) An analysis may be made by the purchaser from a portion of the test ingot in the case of Bessemer steel or from a portion of the drillings from the finished rail in the case of the open-hearth steel, furnished by the manufacturer at the request of the inspector.

(b) When the analysis for carbon made by the manufacturer and the purchaser do not agree the limits for carbon specified in Section 4 shall be extended 0.02 below the minimum and 0.02 above the maximum to cover such variation before rejection of the material.

III. PHYSICAL PROPERTIES AND TESTS.

8. Tests shall be made to determine—

(a) Ductility or toughness as opposed to brittleness.

(b) Soundness.

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*A complete description of the American Standard Pipe Thread is contained in the Pipe Thread Standard prepared under the sponsorship of the American Gas Association and the American Society of Mechanical Engineers, and approved as American Standard by the American Engineering Standards Committee.

†Criticisms of these tentative specifications are solicited and should be directed, preferably before January 1, 1922, to Mr. F. M. Waring, chaiman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

9. The physical qualities shall be determined by the drop test.

10. (a) The drop-testing machine shall be the standard of the American Railway Engineering Association.

(b) The tup shall weigh 2,000 pounds and have a striking face with a radius of 5 inches.

(c) The anvil block shall weigh 20,000 pounds and be supported on springs.

(d) The supports for the test pieces shall be a part of, or firmly secured to, the anvil. These supports shall be spaced 3 feet between centers for rails 110 pounds per yard, or less in weight. The bearing surfaces of the supports shall have a radius of 5 inches.

11. (a) Drop tests shall be made on pieces of rail one or two feet longer than the span between the supports in the testing machine. These test pieces shall be cut from the crop of the top rail of the ingot and marked on the center line of the top surface of the head with gauge marks 1 inch apart for 3 inches each side of the center of the test piece for measuring the ductility of the metal.

(b) The temperature of the test piece when tested shall be between 60 and 100 degrees F.

(c) Where it is necessary to test rails lower than the first rail, the bottom of the first rail, in lieu of the top of the second rail, and the bottom of the second rail, in lieu of the top of the third rail, shall be accepted, if preferred by the manufacturer.

12. Unless otherwise specified, the test pieces shall be tested with the head in tension and with the center punch marks midway between the supports.

13. The test piece shall be subjected to impact of the tup falling free from the following heights:

Weight of Rail, Lb. Per Yd.	Height of Drop, Ft.
70-79 inclusive	16
80-90 inclusive	17
91-110 inclusive	18

14. (a) Under impacts, the rail under one or more blows shall show at least 8 per cent elongation for 1 inch of the 6-inch scale, marked as described in Section 11 (a).

(b) A sufficient number of blows shall be given to determine the complete elongation of the test piece of at least every fifth melt of Bessemer steel and of one out of every three test pieces of a melt of open-hearth steel.

15. For every specimen a record shall be made of the permanent set after each blow under the drop test as measured by the middle ordinate in a length of 3 feet.

16. Test pieces which do not break under the first or subsequent blows shall be nicked and broken to determine whether the interior metal is sound. The words "interior defect" in the following sections shall be interpreted to mean seams, laminations, cavities or interposed foreign matter made visible by the destruction tests, saws, or drills.

17. (a) One piece shall be tested from each melt of Bessemer steel.

(b) If the test piece shows the required elongation (Section 14) all the rails of the melt shall be accepted, provided that the test piece when broken shows no interior defect.

(c) If the test piece does not show the required elongation (Section 14) or, if when broken, shows interior defect, all of the top rails from that melt shall be rejected.

(d) A second test shall then be made of a test piece selected by the inspector from the top end of any second rail of the same melt, preferably of the same ingot. If the test piece shows the required elongation (Section 14) all the remaining rails of the melt shall be accepted, provided that the test piece when broken shows no interior defect.

(e) If the second piece does not show the required elongation (Section 14) or, if when broken, shows interior defect, all of the second rails from that melt shall be rejected.

(f) A third test shall then be made of a test piece selected by the inspector from the top end of any third rail of the same melt, preferably of the same ingot. If the test piece shows the required elongation (Section 14) all the remaining rails of the melt shall be accepted, provided that the test piece when broken shows no interior defect.

(g) If the third test piece does not show the required elongation (Section 14) or if when broken shows interior defect, all the remaining rails from that melt shall be rejected.

18. (a) Test pieces shall be selected from the second, middle and last full ingot of each open-hearth melt.

(b) If all of these test pieces show the required elongation (Section 14) all of the rails of the melt shall be accepted, provided that no test piece when broken shows interior defect.

(c) If any test piece does not show the required elongation (Section 14) or, if when broken, shows interior defect, all of the top rails from that melt shall be rejected.

(d) A second test shall then be made from three test pieces selected by the inspector from the top end of any second rails of the same melt, preferably of the same ingots. If all of these test pieces show the required elongation (Section 14) all the remaining rails of the melt shall be accepted, provided that no test piece when broken shows interior defect.

(e) If any test piece does not show the required elongation (Section 14) or, if when broken, shows interior defect, all of the second rails of the melt shall be rejected.

(f) A third test shall then be made from three test pieces selected by the inspector from the top end of any third rails of the same melt, preferably of the same ingots. If all these test pieces show the required elongation (Section 14) all the remaining rails of the melt shall be accepted, provided that no test piece when broken shows interior defect.

(g) If any test piece does not show the required elongation (Section 14) or, if when broken, shows interior defect, all the remaining rails from the melt shall be rejected.

IV. STANDARD SECTION, LENGTH AND WEIGHT.

19. The section of rails shall conform as accurately as possible to the templet furnished by the purchaser. A variation in height of 1/64 inch less or 1/32 inch greater than the specified height and 1/16 inch in width of base, will be permitted; but no variation shall be allowed in the dimensions affecting the fit of the splice bars.

20. The standard length of rails shall be 33 feet at a temperature of 60 degrees F. Ten per cent of the entire order will be accepted in shorter lengths varying by 1 foot from 32 to 25 feet. A variation of ¼

inch from the specified length will be allowed, excepting that for 15 per cent of the order a variation of ⅜ inch from the specified lengths will be permitted.

21. (a) The weight of the rails per yard as specified in the order shall be maintained as nearly as possible after conforming to the requirements of Section 19.

(b) The total weight of an order shall vary not more than 0.5 per cent from the calculated weight of section.

(c) Payments shall be based upon actual weights.

V. WORKMANSHIP AND FINISH.

22. (a) Care shall be taken in cambering the rails and with the hot-bed work so that the rails will cool with a small but uniform sweep, and, therefore, gagging under the presses will be reduced to a minimum. Rails while on the cooling bed shall be protected from snow, water and excessive gusts of cold wind.

(b) Any rails delivered to the straightening presses showing sharp kinks or greater camber than that indicated by the middle ordinate of 4 inches in 33 feet for the R.E. and R.A. thick-base sections, or 5 inches for A.S.C.E. type of sections, will be at once classed as No. 2 rails.

(c) The distance between the supports of rails in the straightening presses shall be not less than 42 inches. The supports shall have flat surfaces and be out of wind. The application of the gag shall be central between the supports, and the overhang of either end of the rail during straightening shall be supported.

(d) Rails heard to snap or check while being straightened shall be at once rejected.

23. Circular holes for joint bolts shall be drilled to conform to the drawings and dimensions furnished by the purchaser. A variation of 1/32 inch in the specified size and location of bolt holes will be allowed.

24. (a) All rails shall be smooth on the heads, straight in line and surface and without any twists, waves or kinks. They shall be sawed square at the ends, a variation of not more than 1/32 inch being allowed and burrs shall be carefully removed.

(b) Rails improperly drilled or straightened, or from which the burrs have not been removed, shall be rejected, but may be accepted after being properly finished.

(c) When any finished rail shows interior defect at either end or in any drilled hole, the entire rail shall be rejected except that in the case of the bottom rails of the ingot, permission shall be given to cut back to sound metal.

VI. CLASSIFICATION OF RAILS.

25. No. 1 rails shall be free from injurious defects and flaws of all kinds.

26. (a) Rails which by reason of surface imperfections, or for causes mentioned in Section 22, vary from the specifications in a manner which does not impair their soundness and strength, will be accepted as No. 2 rails, but No. 2 rails which contain imperfections in such number or of such character as will, in the judgment of the inspector, render them unfit for recognized No. 2 uses, will not be accepted for shipment.

(b) No. 2 rails to the extent of 5 per cent of the whole order will be accepted.

VII. MARKING AND LOADING.

27. (a) The name of the manufacturer, the weight and type of section of rail, and the month and year of manufacture, shall be rolled in raised letters and figures on the side of the web. The type shall be marked by letters which signify the name by which it is known, for example:

Sections of American Society of Civil Engineers—A.S.C.E.

Sections of American Railroad Association—R.A.—A., R.A.—B.

Sections of American Railway Engineering Association—R.E.

(b) The number of the melt and a letter indicating the portion of the ingot from which the rail was made shall be plainly stamped on the web of each rail where it will not be covered by the splice bars. The top rails shall be letter "A" and the succeeding ones "B," "C," "D," etc., consecutively, but in the case of a top discard of 20 to 35 per cent the letter "A" will be omitted, the top rail becoming "B." If the top discard be greater than 35 per cent, the letter "B" shall be omitted, the top rail becoming "C."

(c) Open-hearth rails shall be branded or stamped "O.H." in addition to the other marks.

(d) All marking of rails shall be done so effectively that the maks may be read as long as the rails are in service.

28. (a) All rails accepted as No. 2 rails shall have the ends painted white and shall have two prick-punch marks on the side of the web near the melt number near the end of the rail so placed as not to be covered by the splice bars.

(b) No. 1 rails less than 33 feet long shall have the ends painted green.

29. All classes of rails shall be kept separate from each other.

30. Rails shall be carefully handled and loaded in such manner as not to injure them.

VIII. INSPECTION.

31. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Proposed Tentative Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement.*

1. These specifications cover cold-drawn steel wire to be used as such, or in fabricated form, for the reinforcement of concrete, in gauges not less than 0.080 inch, nor greater than 0.500 inch.

2. When wire is ordered by gauge number the following relation between number and diameter, in inches, shall apply unless otherwise specified:

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*Criticisms of these tentative specifications are solicited and should be directed, preferably before January 1, 1922, to Mr. F. M. Waring, chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

Gage Number	Equivalent Diameter, In.	Gage Number	Equivalent Diameter, In.
0000000	0.4900	5	0.2070
000000	0.4615	6	0.1920
00000	0.4305	7	0.1770
0000	0.3938	8	0.1620
000	0.3625	9	0.1483
00	0.3310	10	0.1350
0	0.3065	11	0.1205
1	0.2830	12	0.1055
2	0.2625	13	0.0915
3	0.2437	14	0.0800
4	0.2253		

I. MANUFACTURE.

3. (a) The steel shall be made by either or both the following processes: Bessemer or open hearth.

(b) The wire shall be cold drawn from rods hot-rolled from billets.

II. PHYSICAL PROPERTIES AND TESTS.

4. (a) The wire, except as specified in paragraphs (b) and (c), shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	80,000
Reduction of area, per cent	30

(b) For wire to be used in the fabrication of mesh a minimum tensile strength of 70,000 pounds per square inch shall be permitted.

(c) For wire testing over 100,000 pounds per square inch tensile strength, the reduction of area shall be not less than 25 per cent.

5. The test specimen shall withstand being bent cold through 180 degrees without cracking on the outside of the bent portion, as follows:

For wire 0.3 inch in diameter or under, around a pin the diameter of which is equal to the diameter of the specimen.

For wire over 0.3 inch in diameter, around a pin the diameter of which is equal to twice the diameter of the specimen.

6. Tension and bend test specimens shall be of the full-size section of the wire as drawn.

7. (a) One tension and one bend test shall be made for each 10 tons or less of each size of wire.

(b) If any test specimen shows defects or develops flaws, it may be discarded and another specimen substituted.

III. PERMISSIBLE VARIATIONS IN GAGE.

8. The diameter of the wire shall not vary more than 0.003 inch from the size ordered.

IV. WORKMANSHIP AND FINISH.

9. The finished wire shall be free from injurious defects and shall have a workmanlike finish with smooth surface.

V. INSPECTION AND REJECTION.

10. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

11. Wire which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Proposed Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes.†

1. These specifications cover lap-welded and seamless steel and lap-welded iron boiler tubes, boiler flues, superheater tubes, safe ends and arch tubes.

I. MANUFACTURE.

2. (a) The material for lap-welded tubes shall be made by the open-hearth process, or by the knobbled, hammered charcoal iron process.

(b) The material for seamless tubes shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS

3. (a) Chemical analysis will not be required for charcoal iron tubes.

(b) Material made by the open-hearth process shall conform to the following requirements as to chemical composition:

	Grade A.	Grade B.
Carbon, per cent	0.08-0.18	not over 0.03
Manganese, per cent	0.30-0.60	not over 0.03
Phosphorus, per cent	not over 0.04	not over 0.02
Sulphur, per cent	not over 0.045	not over 0.045

4. (a) Analyses of two tubes in each lot of 250 tubes or less, and of 2,000 feet or less of safe end material, may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified in Section 3 (b). Drillings for analysis shall be taken from several points around each tube.

(b) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

5. Tubes of material made by the open-hearth process shall meet the tests specified for steel tubes.

6. (a) For tubes not more than 6 inches in diameter and having a thickness less than 10 per cent of the outside diameter, provided the thickness does not exceed No. 6 B.w.g. (0.203 inches), a test specimen not less than 4 inches in length shall have a flange turned over at right angles to the body of the tube without cracking or showing any flaw. This flange, as measured from the outside of tube, shall in no case be less than ⅛ inch nor more than ½ inch. Within these limits the width of flange shall be not less than 10 per cent of the outside diameter for charcoal-iron, nor less than 15 per cent for steel tubes up to 2½ inches, inclusive. For steel tubes over 2½ inches in diameter and up to 3¾ inches the width of flange shall be 10 per cent of the outside diameter.

(b) For tubes not specified in Paragraph (a) the flange test will not be required.

7. (a) For all tubes, except when the wall thickness is in excess of 10 per cent of the outside diameter, providing the thickness does not exceed No. 6 B.w.g.

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†Criticism of these tentative specifications are solicited and should be directed, preferably before January 1, 1922, to Mr. F. M. Waring, chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

(0.203 inches), a test specimen 3 inches in length shall withstand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is as follows:

Three times the wall thickness for seamless tubes;

Five times the wall thickness for lap-welded tubes.

(b) For all tubes not specified in Paragraph (a) a test specimen 3 inches in length shall withstand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is as follows:

Four times the wall thickness for seamless tubes;

Six times the wall thickness for lap-welded tubes.

8. When required by the inspector, crushing tests shall be made on test specimens 2½ inches in length, which shall withstand crushing longitudinally, without cracking, splitting or opening at the weld, as follows:

Steel tubes: No. 10 B.w.g. or lighter to a height of ¾ inch, or until outside folds are in contact; if heavier than No. 10 B.w.g. to a height of 1½ in.

Charcoal-iron tubes: No. 10 B.w.g. or lighter, to a height of 1⅛ inches; if heavier than No. 10 B.w.g., to a height of 1¾ inches.

9. Tubes under 5 inches in diameter shall withstand an internal hydrostatic pressure of 1,000 pounds per square inch, and tubes 5 inches or over in diameter shall withstand an internal hydrostatic pressure of 800 pounds per square inch; provided that the fiber stress corresponding to these pressures does not exceed 16,000 pounds per square inch. Should the fiber stress corresponding to these pressures exceed 16,000 pounds per square inch, the test pressure shall be determined by the formula:

$$P = \frac{32{,}000\ t}{D}$$

in which P = the pressure in pounds per square inch, t = the thickness of wall in inches, and D = the inside diameter of the tube in inches. Lap-welded tubes shall be struck near both ends, while under the test pressure, with a 2-pound steel hand hammer or the equivalent.

10. A cross-section of charcoal-iron tubes may be turned or ground to a true surface, polished free from dirt or cracks, and etched* until the soft parts are

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Note—In the case of lap-welded tubes, the test shall be made with the weld at the point of maximum bend.

Note—In the case of lap-welded tubes, the test shall be made with the weld at the point of maximum bend.

*A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulphuric acid is recommended for etch test.

Table I—Standard Weights of Lap-Welded and Seamless Boiler Tubes.

Including safe ends, arch tubes and large boiler tubes.

—Thickness—		——Weight, Pounds Per Foot of Length——					
		Outside Diameter, Inches					
In.	B.w.g.	1¾	2	2¼	2½	2¾	3
0.095	13	1.679	1.932	2.186	....	....	....
0.109	12	1.910	2.201	2.492	2.783	3.074	3.365
0.120	11	2.089	2.409	2.729	3.050	3.370	3.691
0.134	10	2.312	2.670	3.028	3.386	3.743	4.101
0.148	9	2.532	2.927	3.322	3.717	4.112	4.508
0.165	8	....	3.233	....	4.114	4.555	4.995
0.180	7	....	....	....	4.460	4.940	5.421
0.203	6	....	....	....	4.980	5.522	6.064
0.220	5	....	....	....	5.357	5.944	6.531
0.229	4½	....	....	....	....	....	....
0.238	4	....	....	....	5.749	6.385	7.020
0.2485	3½	....	....	....	....	....	....
0.259	3	....	4.815	5.507	6.198	6.890	7.582
0.2715	2½	....	....	....	....	....	....
0.284	2	....	....	....	6.721	....	8.238
0.292	1½	....	....	....	....	....	....
0.300	1	....	....	....	7.048	7.849	8.650
0.320	1½	....	....	....	....	....	....
0.340	0	....	....	....	....	....	....

—Thickness—		——Weight, Pounds Per Foot of Length——					
		Outside Diameter, Inches					
In.	B.w.g.	5¼	5⅜	5½	6	7	8
0.095	13	....	....	....	....	....	....
0.109	12	....	....	....	....	....	....
0.120	11	....	....	....	....	....	....
0.134	10	....	....	....	....	....	....
0.148	9	8.064	8.262	8.459	....	....	....
0.165	8	8.960	9.181	9.401	10.282	12.044	13.807
0.180	7	9.746	9.987	10.227	11.188	13.110	15.033
0.203	6	....	....	....	12.568	14.736	16.904
0.220	5	....	....	....	13.580	15.930	18.280
0.229	4½	....	....	....	....	....	....
0.238	4	....	....	....	14.646	17.188	19.730
0.2485	3½	....	....	....	....	....	....
0.259	3	....	....	....	....	....	....
0.2715	2½	....	....	....	....	....	....
0.284	2	....	....	....	....	....	....
0.292	1½	....	....	....	....	....	....
0.300	1	....	....	....	....	....	....
0.320	½	....	....	....	....	....	....
0.340	0	....	....	....	....	....	....

—Thickness—		——Weight, Pounds Per Foot of Length——					
		Outside Diameter, Inches					
In.	B.w.g.	3¼	3½	3¾	4	4½	5
0.095	13	....	....	....	....	....	....
0.109	12	....	....	....	....	....	....
0.120	11	4.011	4.331	4.652	....	....	....
0.134	10	4.459	4.817	5.175	5.532	6.248	....
0.148	9	4.903	5.298	5.693	6.088	6.879	7.669
0.165	8	5.436	5.877	6.317	6.758	7.639	8.520
0.180	7	5.901	6.382	6.863	7.343	8.304	9.266
0.203	6	6.606	....	....	8.232	9.316	10.400
0.220	5	7.119	....	....	....	....	11.231
0.229	4½	....	....	....	....	....	....
0 238	4	7.656	....	....	....	....	....
0.2485	3½	....	....	....	....	....	....
0.259	3	8.273	8.965	....	....	....	....
0.2715	2½	....	....	....	....	....	....
0.284	2	8.996	9.754	....	....	....	....
0.292	1½	....	....	....	....	....	....
0.300	1	9.451	10.252	....	....	....	....
0.320	½	....	....	....	....	....	....
0.340	0	....	....	....	....	....	....

—Thickness—		——Weight, Pounds Per Foot of Length——				
		Outside Diameter, Inches				
In.	B.w.g.	9	10	11	12	13
0.095	13	....	....	....	....	....
0.109	12	....	....	....	....	....
0.120	11	....	....	....	....	....
0.134	10	....	....	....	....	....
0.148	9	....	....	....	....	....
0.165	8	....	....	....	....	....
0.180	7	16.955	....	....	....	....
0.203	6	19.072	21.240	....	....	....
0.220	5	20.629	22.979	25.329	....	....
0.229	4½	....	....	....	28.788	....
0.238	4	22.271	24.813	27.355	....	32.439
0.2485	3½	....	....	....	31.188	....
0.259	3	24.179	26.945	29.711	....	35.243
0.2715	2½	....	....	....	34.008	....
0.284	2	....	29.470	32.503	....	38.569
0.292	1½	....	....	....	36.512	....
0.300	1	....	....	34.283	....	40.69
0.320	½	....	....	....	39.918	....
0.340	0	....	....	....	....	45.971

Note—Seamless tubes are at present not available above 6 inches in outside diameter.

sufficiently dissolved for the iron tube to show a decided ridged surface, with the weld very distinct, while a steel tube would show a homogeneous surface.

11. Test specimens shall be taken from finished tubes. They shall be smooth on the ends and free from burrs. All specimens shall be tested cold.

12. Each tube shall be subjected to the hydrostatic test. One of each of the physical tests specified shall be made from each of two tubes in each lot of 250 or less, and each 2,000 feet or less of safe end material.

13. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 6, 7 and 8, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

14. The standard weights for tubes of various outside diameters and thicknesses are as indicated in Tables Nos. I and II.

Table II—Standard Weights of Small Superheater Tubes.
Seamless Only.

—Thickness—		—Weight, Pounds Per Foot of Length—											
		Outside Diameter, Inches											
In.	B.w.g.	5/8	11/16	3/4	13/16	7/8	15/16	1	1¼	1⅜	1 7/16	1½	1⅝
0.083	14	0.480	0.535	....	....	....	....	....	....	....	....	....	....
0.095	13	0.537	0.601	0.664	0.727	....	....	....	....	....	....	....	....
0.109	12	....	....	0.746	0.818	0.891	....	....	....	....	....	....	....
0.120	11	....	....	....	0.887	0.967	1.047	1.127	....	....	....	....	....
0.134	10	....	....	....	....	1.060	1.149	1.239	1.597	1.776	1.865	1.954	2.133
0.148	9	....	....	....	....	....	1.247	1.346	1.741	1.939	2.038	2.138	2.334
0.165	8	....	....	....	...	....	....	....	....	....	....	2.352	....

15. The weight of any tube shall not be less than that shown in Tables Nos. I and II.

V. WORKMANSHIP AND FINISH.

16. (a) Finished tubes 4 inches or under in outside diameter shall be circular within 0.02 inches, and the mean outside diameter shall not vary more than 0.015 inches from the size ordered. For tubes over 4 inches in outside diameter, these variations shall not exceed 0.5 per cent of the outside diameter.

(b) Tubes shall be gauged with a Birmingham wire gauge, and shall be not less than the thickness specified, except that tubes will be accepted on which the gauge will go on tightly at the thinnest point.

(c) Cold-drawn tubes shall not, at any place, exceed the specified thickness by more than two gauges.

(d) Hot-finished tubes shall not, at any place, exceed the specified thickness by more than three gauges.

(e) The length shall not be less but may be 3/16 inch more than that specified.

17. Finished tubes shall be free from injurious defects and distortion, shall have smooth ends free from burrs and shall have a workmanlike finish.

VI. MARKING.

18. The name or brand of the manufacturer, the material from which it is made, whether steel or iron, and the pressure in pounds at which it was tested, shall be legibly stenciled on each tube.

VII. INSPECTION AND REJECTION.

19. (a) Unless otherwise specified, inspection and all tests, except check analyses, shall be made at the place of manufacture. When required, the manufacturer shall furnish the purchaser of each lot of tubes a statement as to the kind of material of which the tubes are made and that the tubes have been tested and have met all the requirements of these specifications.

(b) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications.

20. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 (a) shall be reported within five working days from the receipt of samples.

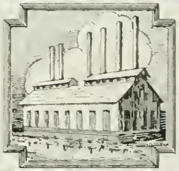
(b) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Superheater tubes when properly manipulated shall stand all forging, welding, and bending operations necessary for application without developing defects. Tubes which fail in any of the above operations will be rejected, and the manufacturer shall be notified.

21. Samples tested in accordance with Section 4 (a) which represent rejected tubes, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

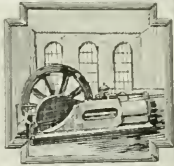
PRIZE FOR BEST DESIGN OF AN APPARATUS TO DETERMINE HARDNESS OF METALS

Sir Robert Hadfield, to whom the John Fritz Medal for his invention of manganese steel will be presented at the opening meeting of the British Institutionof Civil Engineers on June 29, has offered a prize for the best design of an apparatus to determine the hardness of material accurately and suitable for application in metallurgical work for cases in which present methods partially fail, according to an announcement just made here by the American Society of Mechanical Engineers.

The award or awards, which are offered through the Institution of Mechanical Engineers of Great Britain, will be made by the Council of the Institution. The present funds amount to 154 pounds sterling. All communications submitted for the prize should be accompanied by scale drawings or by models or examples of the apparatus, and should reach the secretary of the Institution by December 1, 1921.



STEAM POWER DEPARTMENT



New Diamond Valv-in-Head Soot Blower

One of the Greatest Advance Steps Ever Made In the Soot Blowing Field Has Now Been Made by the Adoption of the New Valv-in-Head Soot Blower.

By ROBERT JUNE.

An entirely new principle has been introduced in soot blower design. The valve, controlling the individual unit, has been incorporated as an integral part of the head. The resultant operating economies are, of course, tremendous. Indeed, it seems safe to say that this is the greatest advance so far made in the soot blower field.

Let us for a moment briefly review recent developments in this important branch of power plant practice. The past few years have witnessed, on the part of engineers everywhere, a marked growth in appreciation of the importance of rapid, thorough, mechanical removal of soot from the heating surfaces of steam generators. Coal and labor have constantly advanced in price. At the same time there have been unprecedented demands upon the boiler capacity of practically every boiler plant. The situation has called for systematic study of every factor affecting combustion. This analysis has proved the mechanical soot blower to be one of the best paying investments in the boiler room.

It has been demonstrated by dozens of tests and by practical experience in thousands of plants that mechanical soot blowers will, on the average, effect such important economies as—a saving of 4 to 6 per cent in fuel—an increase in over-all efficiency of 3 to 4 per cent—a decrease in consumption of steam required for cleaning, and—a marked saving in labor and labor turnover.

In view of these economies, it is not surprising to find that the largest manufacturer of soot blowers has been installing its equipment for several years at the rate of 2,500,000 hp annually.

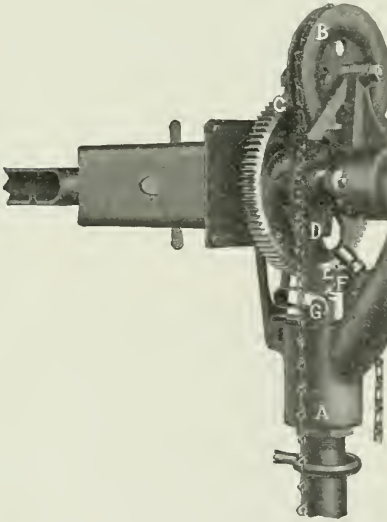


Fig. 1—Assembled Valv-in-Head unit. A—Location of valve in gooseneck. B—Sheave wheel. C—Gear. D—Cam. E—Lever. F—Valve stem. G—Spring.

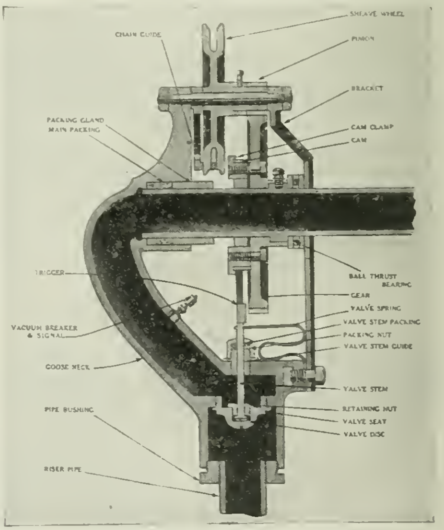


Fig. 2—Cross section of Diamond Valv-in-Head soot blower.

A large measure of the success of the mechanical soot blower has been due to the constant improvement in design and construction. Among the improvements of the past few years are the following:

1. The introduction of calorized metal for the protection of the blower elements from oxidation at high temperatures.

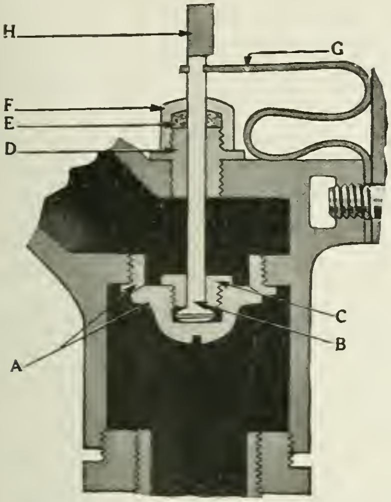


Fig. 3—Cross section of valve. A—Monel metal seat and disc. B—Nickel steel stem. C—Nickel steel retaining nut. D—Brass valve stem guide. E—Packing. F—Nut. G—Spring. H—Trigger.

2. The adaptation of nozzles of a Venturi section to secure the highest possible velocity of the steam jets.

3. The development of special processes for welding these nozzles in place.

4. The designing of steel bearings to support the blower elements.

5. The introduction of the vertical header system of piping.

The successes heretofore registered have proved a spur to further effects. Hence, we have the new Valv-in-Head soot blower, manufactured by the Diamond Power Specialty Company of Detroit, Mich.

Head Constructed on New Principle.

The Valv-in-Head soot blower is provided with a special monel valve of the poppet type, placed at the base of the gooseneck. This valve takes the place of the globe valve which has always heretofore been installed (at a distance of two to fifteen feet or more from the head) in the riser pipe leading from the main header.

The special valve just referred to is located at the point marked "A" in the illustration Fig. 1.

The unit is operated in the following manner: The main control and drain valves, which are the only independent valves on the soot blower line, having first been opened, and all pipes drained and heated, dry steam fills the line to the entrance of the individual valve at the base of the gooseneck "A." The sheave wheel "B" is then revolved by pulling the chain. This turns a small steel cut pinion gear (not visible in the illustration). The small pinion engages the large gear "C" which is fixedly mounted on the blower element. As the gear is revolved, it operates the cam "D," which causes the lever "E" to press down the steam stem "F," causing the valve to open at a pre-determined point in the revolution. After the gear has been further rotated, the cam "D" releases the lever "E," allowing the steam pressure to close the valve at a second pre-determined point in the revolution. As steam leaves the line, the spring "G" holds the valve closed.

Construction of Valve.

The valve is made with Monel metal disc seat. Both the stem and its retaining nut are made of nickel steel. In order to secure extra hardness, which insures durability, the end of the stem is heat treated. A special feature is the provision of a guide on the seat which permits leaving the stem loose in the disc so that the valve will always seat properly. The entire construction is such that the troubles common to globe valves, such as "wire-drawing," leakage, etc., are almost entirely eliminated. Disc and seat are readily accessible so that they may be removed easily for re-grinding or renewal, should occasion ever require.

As the tendency toward high pressure and superheat is very marked in modern power plant design, the company manufactures a special body Valv-in-Head soot blower for such boilers as require this type of equipment.

Cam and Lever Construction.

The movement of the cam is positive, assuring complete automatic opening of the valve at each operation. The cam and the clamps which hold it in place are made of steel. The length and relative position of the cam is individually determined for each unit at the time of the installation.

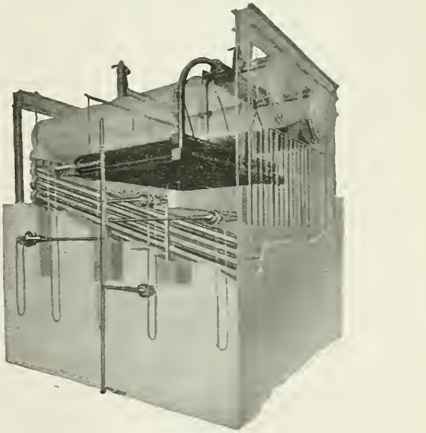


Fig. 4—Application of Diamond Valv-in-Head soot blower system to horizontal water tube boiler, vertically baffled. Basic principles and all features of the Valv-in-Head blower covered by patents issued and pending.

The valve lever, which is also made of steel, is designed with a ratio of two to one, and, as the reduction of the gears is ten to one, the opening of the valve is as readily accomplished as if a lever with a power arm of one hundred inches and a resistance of five inches were used. The spring is made of chrome vanadium. As the spring is away from heat, it always keeps its tension.

Vacuum Breaker and Signal.

A very unique idea has been worked out in the Valv-in-Head blower. Each head is provided with a vacuum breaker for the purpose of preventing the suction of furnace gases into the blower element during the periods when steam is off the unit. In the present head, this vacuum breaker has been designed in the form of a small brass whistle.

During the time that the soot blower is in operation, the whistle sounds, furnishing both an audible and a visible signal, so that there is no opportunity for the operator to leave steam on the unit for a moment during which he is not revolving the blower, without the fact becoming readily apparent to any one in the vicinity.

Chain Guides.

An important feature of the Valv-in-Head blower is the provision of guides to prevent the chain from slipping off the sheave wheel. It is not always convenient for the operator to stand directly under the unit, and the use of the chain guides enables him to operate the blower from any convenient point without facing the possibility of having to hunt up a ladder in order to replace the chain on the sheave. The chain guides, in common with many other parts of the head, are made of steel.

Ball Thrust Bearings.

A very marked step forward has been taken in the design of the Valv-in-Head soot blower through the provision of a ball bearing to relieve the friction caused by the thrust of the unit, due to steam. As will be seen from the cross section of the head, this ball thrust bearing is located directly back of the steel wall bracket which supports the blower element. Its presence relieves the friction so completely that the Valv-in-Head unit turns as readily when the steam is on as when off.

Floating Features of Valv-in-Head.

The necessity for some means of eliminating the binding of soot blower units resulting from movement of the boiler tubes under the forces of expansion and contraction, is now generally recognized. An important development in connection with the Valv-in-Head soot blower is the wall box, with floating mechanism, which provides a means of taking care of any shifting of position of the blower element without causing dislocation of the wall box, cracking of brick work, or expansion strains on soot blower head and brackets.

Advantage of Valv-in-Head Soot Blower.

The advantage of the Valv-in-Head soot blower as compared to soot blowers of the independent valve type, fall into two general groups:

1. Labor—a saving of approximately 50 per cent.
2. Steam—a saving of 20 to 50 per cent or more.
3. Pipe, valves and fittings—a saving of 30 to 66 per cent in cost of pipe, valves and fittings.
4. Maintenance—a reduction in annual charges of 25 to 50 per cent or more. Practically complete elimination of condensate obtained.
5. Efficiency—greater cleanliness of boiler assured.

Indirect Economic Advantages.

The following advantages, while primarily of a mechanical nature, have an important dollars and cents value.

6. Interchangeability—especially adapted to replace other blower heads.
7. One model standard—head is made in one size for all boilers.
8. Control—steam may be intermittently discharged over two or more arcs in revolution. Arc or arcs of steam jets within boiler invariably cover exact pre-determined limits. Speed at which blower element may be revolved is so controlled by reduction gearing as to make improper operation extremely unlikely.

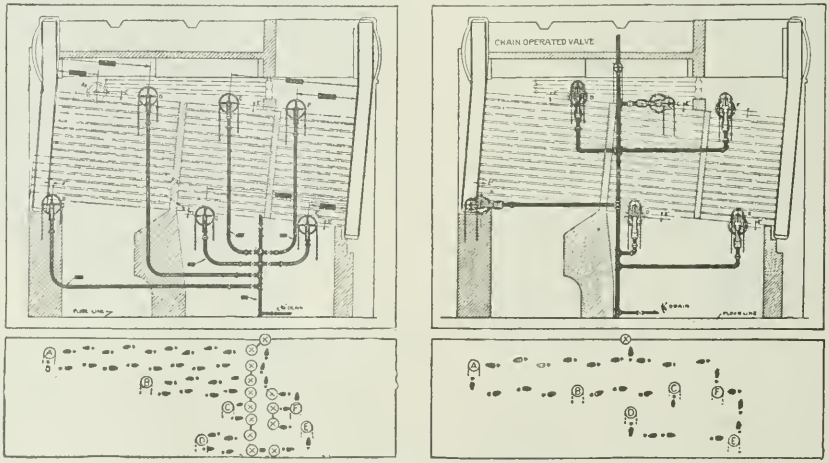


Fig. 5—Saving steps saves steam. The operator of the independent valve system at the left must retrace his steps as shown. Steam is discharged and wasted all the time he is in motion. With the Valv-in-Head system at the right the operator makes a single round trip. No steam whatever is discharged while he is in motion.

Unit provided with visible and audible signal to indicate valve open.

9. One—direction operation—revolution is always clockwise; hence, blower element cannot work loose from head either partially or entirely.

10. Ease of operation—gearing and ball thrust bearings overcome friction.

11. Valve design—time of opening and closing exactly adjusted to soot blower operating conditions, being slower than the standard quick-opening valve and faster than the standard globe valve, thus solving a problem of long standing. Quick-opening valves have the advantage of causing a sharp thrust of the unit, due to rapid admission of the steam. With globe valves, the tortuous passages cause marked reductions in effective pressure. There are also losses of time and of steam, from the slow opening and closing—losses which seem of small amount as respects a single operation, but which become important when spread over a period of time and a number of boilers.

Elimination of Condensate.

One of the most important results of the use of the Valv-in-Head blower is the practical elimination of the possibility of water entering the portion of the soot blower inside the boiler. With the independent valve type of soot blower, the valve is located anywhere from 2 to 15 feet or more from the head. This means that condensation will inevitably take place when the valve is admitted to the cold line. The water thus formed is driven through the soot blower head and into the blower element.

In addition to the condensate thus formed in the line, a more serious possibility is that a small leak in the valve will cause water to form in the pipe before the valve is opened. When this occurs, a solid column of water may be built up in the riser pipes and carried over into the boiler when the valve is opened.

The presence of this condensate in the hot blower element is apt to cause warping, and its discharge on the boiler tubes may cause the soot to pack, forming a gummy mixture hard to remove.

With the Valv-in-Head system, any condensate in the main supply line is discharged through the drain pipes before blowing begins. There is, therefore, no water below the valve which can be carried into the blower head, and the radiation area in the head itself is so small as to be negligible. Hence we have practically complete elimination of condensate from the blower element.

Saving of Labor and Steam.

With the Valv-in-Head system, the length of time of blowing is cut squarely in half. There is no walking back and forth from chain to valve. A single round trip completes the cycle of operations. This effects a marked saving in labor.

Furthermore, a saving in steam of 20 to 50 per cent or more is effected. This saving is a result of the cutting down of losses which occur with the independent valve system when the operator walks back and forth from valve to unit, steam being discharged all the time the man is in motion. Steam is also saved as a result of the Valv-in-Head blower being designed for operation at a pre-determined speed, as this has a marked effect in producing regularity of operation, the blower never being left open longer than the time actually required.

Greater Cleaning Efficiency.

A very marked advantage in the use of the Valv-in-Head soot blower is the increase in effective pressure in the blower element. This is due to two factors. First, the valve offers practically straight passage to the steam, whereas, the steam must take two right-angle turns through the globe valves, which causes an appreciable drop in pressure. Second, the Valv-in-Head system requires about half the quantity of pipe and fittings used with other blowers, and on this account the pressure drop from source of steam to blower element is very much less.

The outstanding advantage of this increase in effective pressure is, of course, the increase in cleaning efficiency of the steam jets. With increased velocity, the range of the steam jets is considerably greater, and the boiler is more thoroughly cleaned in all respects.

Control of Direction of Jets.

One of the results achieved by this design is the positive control of the direction of the steam jets within the boiler. The jets blow only when the nozzles are directed at parts of the boiler from which deposits of soot must be removed. The steam is automatically cut off from the blower element at the precise point in the revolution of the blower element at which the jets would begin to strike the baffles or other parts which might possibly be affected by contact with the live steam.

A striking advantage is that the cam may be so constructed as to permit blowing of the unit at two or more arcs in the revolution. This means that steam may be cut off when the jets approach a baffle, and turned on again when the baffle is passed.

With oil-fired boilers, this ability to control the arc of the steam jets is a particularly valuable feature, since it makes possible the avoidance of interference with draft, to the detriment of combustion.

Gear Reduction Assures Proper Speed of Rotation.

Heretofore it has been a problem to regulate the methods of blowing used by individual members of the boiler room crew. Where one fireman would operate the blowers slowly and in accordance with directions, the next one would yank the chain, spin the blower around and consider that he had done a thorough job of cleaning.

Actually, of course, the boilers are only effectively cleaned when the steam jets play on the tubes for a pre-determined period of time. The gear reduction arrangement provides for the revolution of the soot blower element at a speed regulated to conform to the proper length of time for blowing.

Saving in Pipes, Valves and Fittings.

With the Valv-in-Head soot blower system, a saving is effected of practically two-thirds in the actual length of pipe required.

In Tables I and II, there are given comparative bills of material on a vertical boiler of the Stirling type, for a six-unit soot blower installation of the independent valve system, and the Valv-in-Head system.

Table I.

Bill of Material Independent Valve System
Six-Unit Stirling Independent.

1	2½"	Main control valve	$ 36.01
6	2"	Individual valves at $24.28	145.56
3	¾"	Drain valve, bushing and nipple	6.38
28.5'	2½"	Pipe for main line at $.461	13.15
9	2½"	Unions, ells, crosses, tees	11.39
83'	2"	Pipe for individual risers at $.302	25.07
12	2"	Unions at $.99	11.88
			$249.44

Prices as of May 1, 1921.

Note—Above estimate based on "bronze body valves, nickel seats and discs for pressures of 250 pounds."

For "all steel fittings, with steel body valves, nickel seats and discs" cost would be $404.30.

Table II.

Bill of Material Valv-in-Head System
Six-Unit Stirling Installation.

1	2¾"	Main control valve, with 35' operating chain	$45.01
1	¾"	Drain valve, bushing and nipple	6.38
27'	2½"	Pipe for main line at $.461	12.45
11	2½"	Tees, unions, ells, etc	12.16
25'	2"	Pipe for individual risers at $.302	7.60
9	2"	Union, ells	7.25
			$90.83

Prices as of May 1, 1921.

Note—Above estimate based on "bronze body valves, nickel seats and discs for pressures of 250 pounds."

For "all steel fittings, with steel body valves, nickel seats and discs," would cost $164.82.

With this six-unit installation, the saving in cost of pipe valves and fittings effected by the Valv-in-Head system is approximately 64 per cent. The comparisons are:

Using "Bronze Body Valves, Nickel Seats and Discs."

Independent valve system	$249 44
Valv-in-Head system	90.83
Saving by latter	$158.61

Using "All Steel Fittings, Steel Body Valves, Nickel Seats and Discs."

Independent valve system	$404.30
Valve-in-Head system	164 82
Saving by latter	$239.48

Even should very cheap valves be used, the savings effected by the Valv-in-Head system would amount to 50 per cent.

Future Assured.

The Valv-in-Head soot blower presents so many striking advantages that its future is assured. Indeed, it opens a new page in the history of power plant development.

Modern Steel Works Power Plant

In These Days When Economical Production Is Such a Main Issue In Manufacture of Steel, Power Plants Offer Such Possibilities of Saving That They Must Be Carefully Considered.

By W. N. FLANNIGAN,*
Steam Engineer, Ohio Works, Carnegie Steel Company.

PART III.

SINCE the boiler has a certain range, the same as any piece of equipment, over which it is efficient, and at abnormal loads or underloads, is inefficient, the hand method of forcing the boiler when the pressure drops and ceasing firing when the pressure rises could not be very economical. Even if equipped with instruments the best economy cannot be obtained by hand since instruments do not rekulate or anticipate events, but merely indicate or record conditions after they have happened. This does not belittle instruments as they are also valuable.

Stokers are the equivalent of the automatic valve gear of an engine or the blading of a turbine and assist in obtaining economy, capacity and uniformity. An automatic combustion control system for boilers is the same as the governor on an engine or turbine and just as necessary if fuel is to be burned economically, fluctuations followed and each boiler is to carry its share of the load. With proper automatic control each boiler is compelled to carry its share of the load and the boilers to operate together in parallel the same as electric generators. The load can be proportioned among the boilers as desired to obtain best operating efficiency and reliability.

A good control system is one which will supply fuel, air at the right pressure, and draft to carry away products of combustion, in exact proportion to the load all through the range of operation and which will vary the above at the exact instant at which the load changes occur, not several minutes later. While numerous attempts at automatic control have been made for years, it is only lately that systems have been devised and perfected which can coördinate and control the operation of boilers with any degree of exactness. The latest system uses dc motor driven auxiliaries and, by handling only a quarter of one per cent of the total current used, controls the operation of the boiler with electrical precision and controls it directly by changing fuel and air supply in proper relation and in proportion to the load as changes occur, thus preventing inefficient operation and not merely correcting it after it has occurred. The dampers or induced draft fans in modern installations are now so controlled that the least possible draft necessary to carry away the products of combustion is used, thus reducing air leakage losses to a minimum, but at the same time avoiding a positive pressure in the combustion chamber which forces hot gases and flame into the brickwork causing deterioration.

The savings to be effected in the boiler room are so great that even with automatic control and stokers a good man should be used in the boiler room just as a good engineer is needed in the engine room in spite of automatic valve gear, governors, and safety stops on the engines or turbines.

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*Paper delivered before American Iron and Steel Institute, New York, May 28.

The control systems in a large boiler plant pay close to 100 per cent on the investment in the saving of labor alone as the men are left free to watch the fires and not to act as governors, which results in better fires with fewer men. Likewise, since conditions are corrected as they occur, the fires seldom get into bad shape and high efficiency is continuous.

On account of ease of control, close regulation and the constant speed characteristics obtainable in a motor, as well as better regulation of feed water temperature and economical regulation of exhaust steam supply, motor driven auxiliaries are being widely used. The current for the auxiliaries is usually supplied from a house turbine which exhausts into the feed water heater.

Up to the last year or two ac motors were used, chiefly because the main units were usually ac, and besides furnishing an auxiliary source of power they furnished a means of varying the load on the house turbine and thus the supply of exhaust steam. However, due to the possibilities of electrical boiler control and the wide speed range and desirable characteristics of dc motors, direct current is now being used for auxiliary drive.

Practically every system of control yet devised has been tried in the steel works power plant and every system on the market today is in operation in at least one steel works. The largest part of the development of boiler control has been done in the steel works of this country, urged not only by variable load and desire for economy, but also by adverse labor conditions.

Instrument.

No one would operate a large electric generator without meters to show the voltage, amperes, frequency, power factor, etc., or without indicating and recording or integrating wattmeters, yet boilers and turbines have been operated by hand without any indication of what is going on in them. This attitude was due to two causes: ignorance or lack of interest on the part of the operators, but principally to lack of reliable instruments for making and recording the necessary measurements in boiler operation. The demand for such instruments and their fairly widespread adoption in modern power plants has resulted in a fairly reliable and rugged line of instruments for indicating and recording temperatures, steam, air and water flow, and pressures. Even instruments for automatic flue gas analysis have been greatly improved.

Instruments do not make boiler or turbine efficiency, but paying heed to their indications and warnings does. Practically every modern boiler and turbine installation is provided with flow meters, venturi meters for water, stack and steam temperature thermometers, draft gauges, and in many cases with CO_2 recorders in addition to the original and ever necessary instrument, the steam gauge.

The use of recording instruments is widespread as they not only show the operators the conditions as they occur and enable defects to be immediately corrected, but also show the executives comparative figures from day to day and enable large losses to be stopped at once. One per cent difference in efficiency will pay in less than a year for all of the instruments that can be applied to a 1,000 hp boiler, but without instruments the boiler might run for months at 10 per cent decrease in efficiency without anyone being the wiser unless coal bills were carefully checked. Even then an expensive campaign would have to be started to find the cause of the decrease.

There are very few power plants that will show more attention paid to instruments than is the case in the modern steel works power plant, and this applies not only to the boiler house, but to the engine room and to the electrical equipment as well.

Stack and Fans.

For the average boiler at ordinary ratings without economizers an induced draft fan installation requires about the same investment as a good self supporting stack. However, the power and maintenance costs more than swing the balance in favor of the stack. As the boiler ratings increase or economizers are installed, and with very high horizontal tube boilers, the cost of the stack becomes abnormally large while the cost of the fan installation increases slowly. Therefore, even with the power and maintenance charges the fan becomes the better investment. With ordinary types of boilers the turning point is somewhere around 300 per cent maximum rating. Representative installations both of fans and of stacks are to be found in steel works power plants, fans being used both with and without economizers.

Unlined steel stacks and guyed stacks are practically a thing of the past in steel works power plants. Breechings and flues are also lined, either with brick or with a comparatively thin prepared asbestos lining. Concrete and brick stacks were brought to steel works by the coke plants on account of their corrosion resisting properties. The concrete stack after several years of trial has proven to be very satisfactory, and due to its reasonable first cost and freedom from maintenance is to be found in many power plants.

Coal and Ash Handling.

Coal and ash handling machinery in the boiler house is usually a specialized form of hoisting and conveying machinery and is fairly well standardized. The most notable features in the latest plants are the widespread use of belt conveyors, the reliability attained by them, provision for thorough mixing of coal and coke breeze in some plants, and the installation of boilers at such an elevation that standard railway cars can be run directly under the ashpits. Large sliding ash gates, air operated, are usually installed so that poking or bridging of ashes and clinker is eliminated. It is not economy to tie an expensive boiler house up to an unreliable coal or ash handling system and the elevated building scheme is certainly the most reliable ash handling system possible, as there is nothing to get out of order or to be operated, except the ash gates, and even if one does not work, the ash pit can be practically emptied by the other gates, since two or more are usually installed under each boiler. It is a difficult matter to show beforehand the exact saving by elevating the boilers and using standard railway cars for ash, but with all of the companies that have, or have had various systems in operation, this system is adopted as standard, and practically no other is considered for stoker fired central stations or steel works boiler houses unless local conditions seriously interfere.

Water Softening.

Many steel works lose yearly, due to dirty feed water, the cost of a good water softening plant. This statement at first appears questionable, but will bear considerable attention. Aside from the loss of efficiency due to scale, which fact no one questions although authorities disagree as to the amount, there is a high labor charge in cleaning and repairing and considerable loss of tubes, even if the water contains no corrosive substances. There is also a fuel loss in heating up boilers and deterioration of the settings due to shutdowns. In addition there is an investment in spare boilers which are necessary to permit others being cleaned and repaired, and which could be decreased if good feed water were available. Not all of the above loss can be saved by a water softening plant, because it is impossible to completely purify the water and they cost something to run, but the largest part of the amount can be readily saved.

The saving due to clean feed water does not end in the boiler house, but extends throughout the entire plant as clean feed water means cleaner steam and its freedom from powder and dirt, which scores engine cylinders, causes leaky valves and reduces turbine efficiency.

The cost of clean feed water can be written off the books on either of two entirely different accounts. The first has been mentioned, the second is safety. Large investments are being made for safety and no industry has made greater progress than the iron and steel industry. A water softening plant is one of the best safety installations that can be made, and is rapidly being recognized as such. Modern boilers from which high ratings are expected have to meet more severe conditions than older installations, and the danger of bursted tubes or explosions is very much greater unless good feed water is supplied. Therefore, from a safety standpoint clean feed water is becoming more and more essential, as more is expected of boilers and the design of the boiler proper has not changed commensurately.

Formerly evaporators were used only in chemical processes, or on shipboard where salt water compelled their use, whether economy was desired or not. Now an evaporator for make-up water for boiler feed is a standard piece of equipment in central stations except where corrosive water compels the use of jet condensers.

Some of the largest and best equipped water softening plants in this country have been installed in steel works, which shows that steel works engineers have found that pure feed water is as much of a necessity as the boiler itself, if modern conditions are to be met.

Pressures, Etc.

The steam turbine and the uniflow engine, particularly the former, offer a means of obtaining the economies that can be effected by the use of higher pressures and temperatures. The standard pressure for new steel works installations is now 250 pounds per square inch instead of 150 pounds. A pressure of 350 pounds is being accepted as standard by central station men and seriously considered by steel works engineers, while still higher pressures are discussed in this country and at least one plant is to be installed abroad for 500 pounds per square inch. The only questions that can be raised are, "Is the high pressure equipment too expensive," and "Can high pressures be used safely and without too much operating trouble?" To the steel works man, high pressures are common, as hydraulic pressures run into thousands of pounds. However, for steam to be used economically, it should be superheated and the higher the pressure the higher the initial temperature should be on account of the moisture formed as it is expanded in a turbine It is the temperature which causes trouble, not the pressure, and most of the efforts of the designers and metallurgists are now expended to take care of weakening effect of temperature and the difference in expansion of different metals used. The solution of the problem seems to be to start with a high initial pressure and to superheat between stages similar to reheating in the receiver of a compound engine This would require only a reasonable initial temperature even for 500 pounds pressure and would eliminate most of the temperature troubles.

Piping and valves have proven to be the weakest link in most of the high pressure, high superheat stations. Boilers can be designed and operated just as safely on 350 pounds per square inch as on 150 pounds, except that at much above 350 pounds plates and rivets become unwieldy and the present standard designs of boilers would have to be modified. Turbines, except for packing troubles, have given little trouble traceable to high pressures and temperatures. Most of the trouble has occurred in the low pressure stages where pressures and temperatures are lower.

This is the age of steel in high pressure plants. Cast iron has been practically eliminated in boiler construction, in piping, valves and fittings and in at least part of turbine casings. The demand now is for high grade steel and workmanship in pipe and valves, which combined with welded joints would practically eliminate trouble from that source.

On account of the immense amount of auxiliary equipment and the large investment in buildings required for a modern power plant the additional cost of the high pressure, high superheat equipment over lower pressures is only a fraction of a per cent of the total cost. For instance, the difference in cost of a 1,300 hp boiler and feed pump from 200 to 250 pounds is only $3,170 and there is no difference in the cost of piping and valves. From 250 to 350 pounds the difference including the proportionate cost of piping, valves and all accessories is about $6,000. There is no difference in the cost of a 10,000 kw turbine from 200 to 250 pounds per square inch and only $9,000 difference between 200 and 350 pounds per square inch. The increased cost of repairs is at least partially over-balanced by cheaper condensers and less condenser power on account of the decreased steam consumption at high pressures and by decreased demand on the boilers.

The interest on the increased investment figures out very high and, although actual operating costs are not as yet available, the fact that new plants are being installed and contemplated at 350 pounds per square inch shows that the savings are actual and not merely theoretical.

In the average steel works there are many existing prime movers in good condition, some of which are of recent date, but all operating on 150 pounds saturated steam. To obtain many of the benefits of high pressure, high superheat steam without interfering with present equipment and without excessive first cost, the following scheme was first contemplated for steel works and is actually being installed in the rubber industry. High pressure boilers with superheaters would be installed giving a pressure of up to 350 pounds per square inch and 150 to 200 degrees F. superheat, and the steam passed through turbines which would exhaust at 150 pounds and 75 degrees F. superheat, or lower as desired, into the existing steam mains supplying the engines, gas producers, etc., around the plant. The turbines would drive electric generators furnishing part of the electrical power for the plant. In this way 20 per cent more power would be obtained with 4 per cent additional coal consumption and in addition the economy of all existing units would be increased due to the superheat.

Superheaters.

The saving in steam consumption due to superheat varies from ½ to 2 per cent for every 10 degrees F.

depending upon the design of the unit, being greatest for engines and small turbines and least for large turbines. Therefore, there is quite a saving possible in steelworks, where engines are widely used, the extent of which is limited by the ability of the engines to withstand the temperature. At 150 pounds pressure even large Corliss engines can operate without valve trouble at 70 degrees or more superheat, so in many cases superheaters from 70 to 100 degrees F. at the boilers are installed. Piston and poppet valve engines can withstand still higher temperatures, but the plant is usually limited by Corliss engines. The above conditions can also be well withstood by existing piping systems without radical changes. The saving is due, in engines, to decreased cylinder condensation and to greater specific volume of the superheated steam; and in turbines, mainly to eliminating blade friction of the moisture in the steam.

The necessity of superheat in order to obtain full advantage of higher pressures as well as the economy obtainable thereby with lower pressures and the use of superheated steam in coke and benzol plants for distillation, has resulted in superheaters being included in practically every new steel works boiler installation and in many older boilers being so equipped.

Engines and Turbines.

In order to obtain the economies of electric drive in the steel works and to meet the increasing electrical demand, larger turbines are being installed than formerly. While there are no exceedingly large units in steel plants, still there are many installations of from 10,000 to 20,000 kw, which sizes give good economy and compare quite favorably with central station practice. Units up to 45,000 kw in a single casing and up to 60,000 kw in a three casing machine have been installed in some of the largest stations, but turbines of this size are not required as yet for the steel industry on account of the immense amount of steam driven equipment in the plants and the desirability of having spares rather than tying all of the generating capacity up in one large unit.

While the turbo-blower, on account of the small turbine size and lower blower efficiency, cannot equal the economy of a gas engine or even the modern steam engine, its other advantages of close regulation, accurate air delivery, and small space and labor requirements have caused its adoption in many plants. Although some of the earliest units caused trouble and doubt, the later units appear to be quite satisfactory and turbo-blowers are a feature of some of the latest blast furnace installations.

The same conditions that have increased steam pressures for turbines and fostered the use of electric drive have caused pressures and temperatures for engines to approach those used in turbine practice. For instance the latest reversing engine installation is designed for 225 pounds per square inch pressure and 125 degrees F. superheat at the throttle. A noticeable feature of this engine is its simplicity and accessibility. While the twin-tandem engine is standard in the United States at present, it seems as though in order to fully utilize higher pressure and superheat that triple-tandem compound or multi-cylinder uniflow reversing engines may be the future competitors of electric drive. Triple-tandem engines have been built in Europe and have the advantage of lower inertia forces in addition to being better able, on account of smaller cylinders, to use higher pressures and temperatures. Reversing uniflow engines have been built for locomotives and for boats, but not as yet for rolling mills in this country, although the manufacturers appear to be willing.

For continuous running mills the uniflow engine is rapidly coming into prominence. The early installations have shown great reliability, while the economy of the uniflow over wide load ranges is almost an accepted fact. In this country last year there were three new installations for driving rolling mills, two of which were duplex engines; also several electric power installations. Two 40" x 48" duplex uniflow engines, which have just been completed for hot mill drives, will develop an average of 2,500 hp and a maximum of 5,000 hp each. Two more uniflow engines, one a 28" x 42" duplex and the other a 40" x 48" single engine are now being built. Governors have been developed with a very reliable and easily operated speed-changing device so that all conditions of service can be met. In view of the numerous installations of electric mill drives, the status of the steam engine for roll drives appears to be dependent upon how much use is made of the economies to be effected by high steam pressures and temperatures, either by the use of pressure reducing turbines, or by direct application to the engine.

Condensers.

For years the barometric condenser was the standard for steel works on account of freedom from corrosion and repairs, and ability to use dirty water. This type of condenser, also, if properly designed can hold a fair vacuum even if the air pump is out of operation.

The advent of the turbine, which utilized a much higher vacuum than the steam engine, necessitated an abnormally large exhaust pipe to keep friction losses down to a minimum. Therefore, the low-level jet and surface condenser, which could be attached directly to the turbine exhaust, were used for large installations as is the practice in central stations. While corrosive or exceedingly dirty water compels the use of the jet condenser, as all parts can be made of cast iron and cleaning is reduced to a minimum, the surface condenser offers many economies. A surface condenser will cost from 50 per cent to 75 per cent more than a low-level jet type, but it saves the condensate and requires less power to operate.

Even though the condenser in question condenses only a fraction of the total steam of the plant it will save the difference in cost in a short time from the feed water saving alone, as is shown by the following calculation, by eliminating the necessity of treating that amount of water and, in case untreated water is used in the boiler, the saving will be at least double that shown.

Size of turbine	10,000 K. W.
Cost of surface condenser	$75,000
Cost of low-level jet condenser	45,000
Difference	$30,000
Cost of feed water from water softening plant	$0.07 per 1,000 gallons

Condensate per hour equals $\frac{10{,}000 \text{ kw} \times 13 \text{ lbs. per kwh}}{8\frac{1}{3}} = 15{,}600$ gals. per hr

Value of feed water saved per hour $\frac{15{,}600}{1{,}000} \times \$0.07 = \$1.09$

Value of feed water saved per year of 310 days $310 \times 24 \times \$1.09 = \$8{,}120$

Interest on investment from feed water saving alone $\frac{8{,}120}{30{,}000} = 27\%$

or the difference paid for in about three years.

The water softening plant can be made smaller on account of the surface condenser resulting in a saving in investment of approximately $10,000. In addition there is a saving in power of $12,000 per year if motor driven auxiliaries supplied from the turbine are used. This is due to less air-pump power on account of not having to remove air from the circulating water and to lower circulating water head. Thus there is $8,120 plus $12,000 or $20,120 saving per year on an investment of $30,000 less $16,000 or $14,000.

The surface condenser has a further advantage of furnishing an absolute check on turbine performance if the condensate is metered. While the difference in first cost as shown cuts little figure on account of the savings effected, more labor will be required for cleaning and packing and there will be some drop in vacuum between cleanings if the water is very dirty. However, unless the water is very slimy or corrosive, a surface condenser pays, and in spite of the lead which the barometric type had, surface condensers are being widely used in the steel mills and furnace plants.

Gas Engines.

The modern blast furnace gas engine shows much greater reliability and a somewhat higher thermal efficiency than formerly, but the steam turbine plant when high pressures and superheat are used and all auxiliaries such as gas washers, are taken into consideration, runs a pretty close second in regard to economy and can be installed at a much lower figure. However, all of the possibilities of the gas engine have not been taken care of, although some work has been done along this line in this country and considerable in Europe. By utilizing the heat of the exhaust and the heat of the jacket water the thermal efficiency of the entire system can be made at least double that of the engine alone. In one plant in the United States the exhaust is to be used to run a high pressure boiler; in Germany low pressure boilers and low pressure turbines are used to some extent. In another plant the equivalent of 100 boiler hp per 3,000 kw engine is obtained by a very simple and inexpensive air heater which is used to heat the buildings and which increases the back pressure on the engine less than two inches of water. However, this last is only used in winter and could be made more effective as up to 300 boiler hp is readily available from the exhaust.

The use of jacket water as boiler feed water is another method of improving the economy of the system by saving the jacket water loss, and enabling the gas engine to compete with steam driven equipment in spite of high cost. This is already being done and other installations contemplated, in connection with economizers, utilizing the heat in the exhaust gas. This is an almost ideal source of waste heat as the jacket water is not contaminated and the exhaust gases are quite clean. The only consideration is to not create too high a back pressure on the engine.

Air Compressors and Hydraulic Pumps.

Systems of even somewhat minor importance in comparison to the main power supply have received considerable attention in many plants. For instance the air compressing and distributing systems have been carefully studied, resulting in the installation of large central compressors in the power house and the elimination of small isolated compressors. This results in better attention with less labor, as the compressors are under attendance of the power house employes, greater reliability, and much better economy. The compressors themselves are not only more efficient, due to larger size and condensing operation, but steam lines to the isolated compressors with their accompanying radiation losses are replaced by air lines with no heat loss. In connection with the central compressors, after-coolers are installed to prevent freezing of condensation in the exposed air lines. A few noteworthy installations of the air-cooled type have been made and are operating successfully.

The same tendency to centralize is evident in the hydraulic systems. In addition to centralization of pumps the economy is carried also throughout the entire system by properly proportioning cylinders to the load, better attention to operating valves and packing, but particularly by the use of clean water. Clean water reduces valve trouble, both in the pumps and operating valves, plunger scoring, and greatly decreases the quantity of hydraulic water used. While many plants use water from the water softening system for hydraulic make-up, in some cases separate filters have been installed and found to result in a saving of labor as well as greater reliability.

THE HARDNESS OF ELECTROLYTIC IRON

In the year 1906, Dr. H. C. Boynton, of Harvard College, communicated to the Iron and Steel Institute an account of experiments on the "Hardness of Constituents of Iron and Steel," interesting also on account of the method by which he determined the hardness. He made use of the microsclerometer of Professor T. A. Jaggar, also of Harvard, in which a fine diamond point is rotated at very high speed and the depth of the hole drilled is measured. Experimenting on pure electrolytic rion .ferrite, Boynton found that the etching of the original or remelted specimens made no difference in the hardness, the relative hardness figures being 505 and 460, but that quenching from high temperatures doubled the hardness, quenching at 850 degrees C. (B iron) raising the hardness to 998, and qeuching from 1,300 degrees C. to 982. In Stahl und Eisen of May 12 last, Drs. V. Bauer and W. Schneider, of the Technical High School at Breslau, describe experiments, made by a different method, which do not show this marked influence of quenching. They took cubes of electrolytic iron, of 10 mm edge, normalized by heating to 950 degrees C. for half an hour, and quenching them from eight different temperatures ranging from 650 degrees up to 1,250 degrees C. Determining the hardness by the Brinell method, they found no influence of the quenching temperature at all, all the hardness values lying between 57 and 59.3. They do not question the accuracy of Boynton's results, however, but point out that the Brinell hardness is not the hardness of Boynton. The former marks the resistance which the material opposes to penetration of a harder substance into it, while the Jaggar method measures the resistance opposed by the smallest particles to the rotating diamond. Brinell hardness and capability of being machined do not go together; austenitic manganese steels are soft and yet difficult to machine, while the Boynton hardness would indicate the relative ease with which the material can be machined. Bauer and Schneider also made tensile strength tests, on strips of 16 mm by 2.5 mm cross-section, 120 mm long, without finding any noteworthy differences caused by quenching, and other tests with turned rods, reheated in a vacuum, were equally concordant. But Bauer and Schneider did not extend their examination to various steels at Boynton had done.

WITH THE EQUIPMENT MANUFACTURERS

There are probably more difficult engineering problems met in the design and building of electrically driven cranes than in any other standard line of machinery. Not only are the cranes used for radically different kinds of work, but the dimensions, the speeds, and numerous other factors are constantly being altered.

Among some of the more peculiar demands are those for cranes to travel around curves, others to run on a straight track part of the time and the remainder on a curved track, and for others to travel in complete circles.

A patent was recently secured on a method of driving a crane on a circular track by R. W. Valls, vice president and general manager of The Champion Engineering Company, Kenton, Ohio, builders of Champion cranes. This is said to be quite an improvement on former devices, and the illustration shows quite clearly how the object is accomplished.

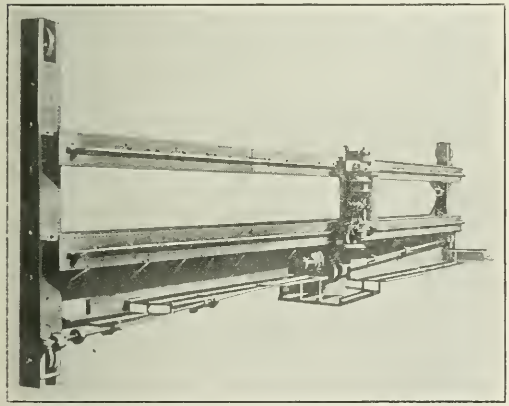


Fig. 1.

On cranes of this kind it has been customary to make the track wheels for the outer radius considerably larger than those for the inner track, and to use different sizes in gears and pinions. This meant complication in design, having various sizes of gears and pinions, and keeping many more "spares" on hand, the parts not being interchangeable.

With the construction shown, all track wheels, gears and pinions are of a size, excepting one gear and pinion at the center of bridge. This allows the use of one size gear case It simplifies the construction greatly, reduces upkeep cost and the repair time.

The crane shown was built for the round house of the Pennsylvania Lines, Columbus, Ohio, and notwithstanding the span is 75 feet, it is said the loss in traveling the complete circle is but one-eighth inch. It has been the cause of many most favorable comments.

All cranes have a tendency to get out of square on the runways, this being emphasized on cranes on curved tracks. By a very simple device, covered by the same patent, the crane may be squared up again in a few moments. This squaring up device is applicable as well to cranes operating on straight tracks as the differential gear provided forms the correcting means for accomplishing that purpose.

GAS MASK FOR CARBON MONOXIDE PERFECTED.

The first public demonstration of the gas mask for protection against carbon monoxide, manufactured by the Mine Safety Appliances Company, Pittsburgh, Pa., and in which is utilized the special chemical mixture called Hopcalite, developed by the United States Bureau of Mines and Chemical Warfare Service, United States Army, was given the afternoon of May 26 in the special smoke room of the United States Bureau of Mines, Pittsburgh, Pa. The United States Bureau of Mines in its research of various types of gas masks, including the carbon monoxide mask, has a large smoke room especially adapted for testing purposes, and the courtesy of the use of this smoke room was extended for this demonstration. In addition the first public demonstration was also given of the United States Bureau of Mines Gas Mask for city firemen, also containing Hopcalite, for carbon monoxide protection.

In this test two men entered the smoke room which contained 1 per cent of carbon monoxide gas in the air. One of the men carried a canary bird into the room to indicate to the observers the poisonous nature of the atmosphere. The canary bird collapsed in 45 seconds, and was immediately removed to fresh air, where it was revived with oxygen.

Tests were also frequently made with the M-8-A Carbon Monoxide Detector to show the observers the strength of the gas. The wearers of the mask remained in the atmosphere for 30 minutes, doing vigorous work part of the time, and experienced no ill effects whatever from the poisonous carbon monoxide gas. The gas masks gave perfect protection throughout the entire period of the test.

The carbon monoxide gas mask is of special interest to iron and steel industries, fire departments, industries using gas producers, illuminating gas plants, coal and metal mines and to all other persons who are apt to encounter carbon monoxide gas in their work.

Carbon monoxide occurs frequently in dangerous quantities around blast furnaces, gas producers, etc., and is a constant hazard because of its poisonous nature. A simple protective device, light in weight, devoid of all complicated mechanisms has long been needed for the protection of men engaged in such work.

While the gas mask used will give protection in higher percentages of carbon monoxide, 1 per cent of carbon monoxide in the air will kill a man in a few minutes' time. The percentage found in working places where there is ventilation usually amounts to considerably less than 1 per cent.

One-tenth of 1 per cent of carbon monoxide, however, will seriously effect a man who is working and therefore breathing hard in about one-half hours' time, while two-tenths will effect him seriously in about 10 minutes' time.

The carbon monoxide gas mask is therefore of great importance to the country's industries and it is important to note that a splendid accomplishment of the United States Bureau of Mines and Chemical Warfare Service in their work on poisonous gases during the war has been adapted to a most important industrial use.

NEWS OF THE PLANTS

The Richard French Iron Works, Worcester, Mass., has acquired property on Howe avenue, Millbury, for the erection of a new plant for the manufacture of general iron products. The proposed works will replace the company's plant at Worcester, recently purchased by the Arcade Malleable Iron Company, a branch of the Baldwin Chain & Manufacturing Co. Plans for a number of buildings are nearing completion, with main structure to be 50 x 120 feet, and a number of smaller buildings adjoining. Construction will be inaugurated at an early date, and the plant ready for service in the early fall.

The Whitaker-Glessner Company, Portsmouth, Ohio, has placed its new continuous sheet mill for rolling bars in operation, bringing considerably increased production in this department of the works. The plant consists of six stands of 18-inch roughing and finishing rolls, supplemented by two edging mills. The rated output approximates 40,000 tons of 10-inch sheet bars per month. A new power plant has also been installed, with extensive capacity to provide for future contemplated extensions.

The Wheeling Steel Company, Wheeling, W. Va., has preliminary plans under way for the erection of a number of additions to its La Belle Iron Works, Steubenville, Ohio, providing for considerable increased capacity. It is proposed to make this the leading plant unit of the recent merger of steel interests under the Wheeling Steel Company name. A number of new buildings will be erected and improvements made in present structures. The work, including machinery, is estimated to cost in excess of $1,500,000.

The American Wire Fabrics Company, 208 South La Salle street, Chicago, Ill., has completed plans for the erection of a new galvanizing plant at its works at Blue Island, Ill., to be located on Western avenue. The structure will be one story, 48 x 145 feet, and will be supplemented by another structure to be used for general storage and works service. The buildings will cost about $100,000.

Luria Brothers & Co., Lebanon, Pa., iron and steel products, has perfected plans for the establishment of a new yard in the North Side District, Pittsburgh, Pa. It will be fully equipped to handle small and large material, with installation provided for covering locomotive cranes, shears, and handling equipment. It is proposed to place the yard in service at an early date.

The Chester Iron & Foundry Co., 7800 Vulcan street, St. Louis, Mo., has completed plans for the erection of two additions to its plant for increased capacity. The main structure will be 45 x 115 feet, and will be used for general operating service, while the other building will be 20 x 35 feet. A. J. Schaelich is president of the company.

The Cleveland Structural Steel Company, 6600 Park avenue, Cleveland, Ohio, is completing plans for the erection of a one-story addition to its plant on Highland avenue for increased production. It will be 55 x 112 feet, and is estimated to cost about $25,000.

The Birmingham Steel Company, Birmingham, Ala., is being re-organized under an agreement with creditors, who recently filed a petition in bankruptcy against the company. The plant will be operated in the future as an independent steel fabricating organization, and present affiliation with the Mobile Shipbuilding Company will be discontinued. The corporation is said to be solvent, and extensive production plans are under way in connection with the re-organized company.

The Empire Rolling Mill Company, Bessemer avenue and Pennsylvania Railroad, Cleveland, Ohio, has commenced the erection of a new steel galvanizing plant, to be one story, 50 x 130 feet. A warehouse building will also be constructed. The entire work is estimated to cost close to $55,000. C. G. Borkwell is president.

The A. C. Chesley Company, Inc., 277 Rider avenue, New York, N. Y., manufacturer of fireproofing steel products, has acquired property on East One Hundred and Thirty-second street, extending through to East One Hundred and Thirty-third street, between Cypress and Willow avenues, for the erection of a new plant. The site adjoins a works recently completed by the company and the extension will be used for plant expansion and general increased production. Plans for the new plant will be prepared at an early date.

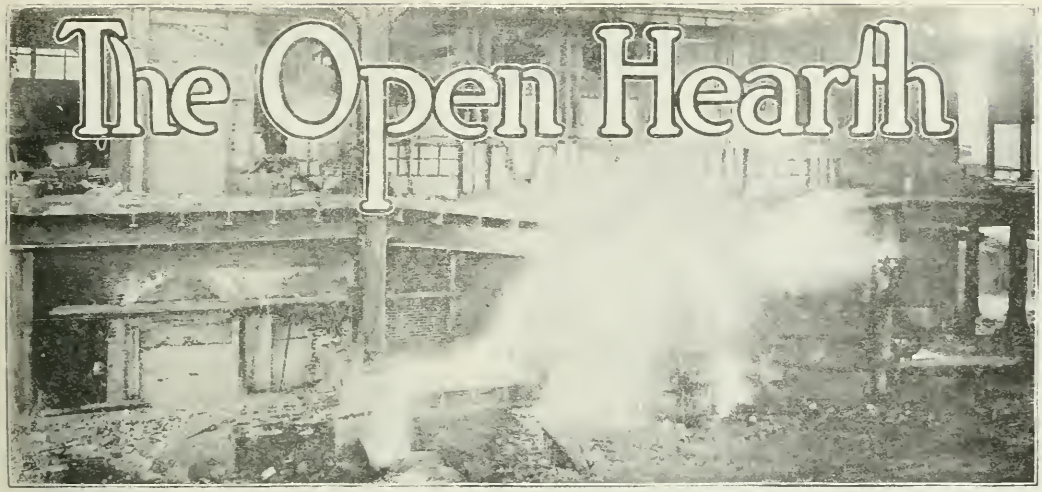
The Terre Haute Boiler Works, Terre Haute, Ind., is planning for the erection of a new one-story plate mill, estimated to cost about $75,000 with machinery. The structure will be used for fabricating work in connection with boiler and tank construction.

The Samuel Uris Iron Works, Gerard avenue and One Hundred and Fifty-seventh street, New York, N. Y., is said to have plans under way for the rebuilding of the portion of its plant recently destroyed by fire with loss estimated at close to $30,000.

The Virginia Bridge & Iron Company, Roanoke, Va., with plant at Memphis, Tenn., has acquired local property, consisting of the former works of the Anchor Saw Mills on the Wolfe River, comprising about 10 acres of land. The company will commence the immediate remodeling of the plant and install equipment for the manufacture of all-steel barges. The company will use its fabricating works at North Memphis in connection with the barge plant. Orders have been taken for the construction of a number of barges at the earliest possible date.

The Paragon Foundries Company, Oregon, Ill., manufacturer of iron plates, etc., is having plans prepared for the erection of an addition to its plant for increased production. It will be one-story brick, 100 x 200 feet, and is estimated to cost about $50,000. Bids will be taken at an early date. James Reed is president of the company.

The New England Steel Casting Company, Shaker Road, East Longmeadow, Mass., is planning for the rebuilding of its local plant, recently destroyed by fire, with loss estimated at close to $100,000, including equipment.



The Open Hearth

Floyd Rose, secretary of the Heppenstall Forge & Knife Co., Pittsburgh, was recently made general manager of sales of the Heppenstall Forge & Knife Co., and also of the Heppenstall Forge Company.

V V

Wm. B. Schiller, president of the National Tube Company, sailed July 1 for Europe.

V V

L. A. Holmes, engineer, McClintic-Marshall Company, Pottstown, Pa., has been transferred to the Boston office of that company.

V V

H. W. Bishop, Jr., recently resigned from the LaBelle Iron Works, Steubenville, Ohio. Mr. Bishop was connected with the general sales office of this company for 10 years, and since the consolidation of LaBelle Iron Works, the Whitaker-Glessner Company and the Wheeling Steel & Iron Co., identified with the Pittsburgh sales office of the Wheeling Products Company. It is understood that he will make a connection with an Eastern steel company.

V V

Isaac Harter, assistant to the president of the Babcock & Wilcox Co., 85 Liberty street, New York, builder of boilers, stokers, etc., has been appointed general superintendent of the company, succeeding the late James P. Sneddon.

V V

S. V. McLeod was recently appointed purchasing agent of the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ont., succeeding L. L. Jacobs, resigned. Mr. McLeod's headquarters are in Sault Ste. Marie.

V V

Robert Palm, who was formerly connected with the Chrome Steel Works, Chrome, N. J., as chief engineer, is now with the export department of the Texas Company.

V V

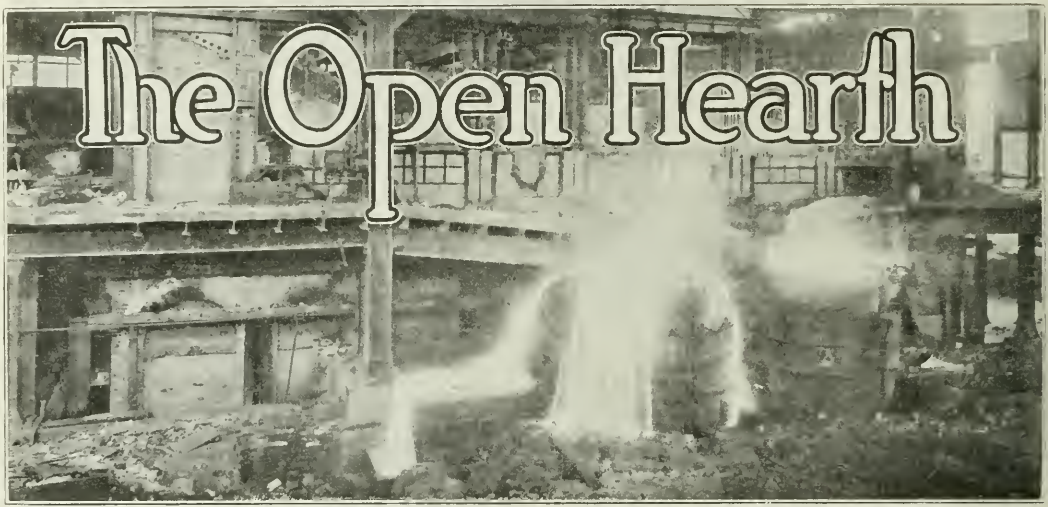
Dexter S. Kimball, whose nomination for the presidency of the American Society for Mechanical Engineers recently was announced, in addition to being dean of the College of Engineering, Cornell University, is one of the country's best known engineers and has been active in promoting a closer union of engineering organizations. With Herbert C. Hoover, now Secretary of Commerce, he aided in organizing the Federated American Engineering Societies, and is one of the vice presidents of the American Engineering Council, the executive branch of that federation.

V V

Walter S. Tower, who has been trade adviser of the Consolidated Steel Corporation, New York, took up, on Monday, July 11, work with the Department of Commerce, to which he has been assigned by Secretary Hoover. While Mr. Tower's position has not been clearly defined, it is stated, contrary to press reports, that he will not be the chief of an industrial division on iron and steel, at least not in the immediate future. His first task is expected to be in connection with a request made by the United States Shipping Board to the Department of Commerce, to assist the former in the organization of work looking to the gathering and analysis of shipping statistics. Mr. Tower, who is 40 years of age, was born in West Bridgewater, Mass., where he obtained his public school education. He is a graduate of Harvard, getting the degrees of A.B. and A.M. in 1903 and 1904, respectively, and also graduated from the University of Pennsylvania with the degree of Ph.D. in 1906. For a series of years, and up to 1917, he was engaged in teaching and traveling. While traveling he studied trade conditions, chiefly in North and South America. After that, he became connected with the Shipping Board. He has written several articles concerning Latin-American trade conditions. During the war he was associated with the Division of Planning and Statistics of the Shipping Board. Upon the resignation, in March, 1919, of E. F. Gray, as director of that division, he was succeeded by Mr. Tower, who remained in that position until June, 1919, when he went with the Consolidated Steel Company.

V V

Carl A. Wendell, of New York, who was in charge of coal washing investigations for the Unitd States Steel Corporation at Joliet, Ill., from 1908 to 1913, has been made consulting engineer of the Federal Bureau of Mines in matters pertaining to coal washing and preparation. Since leaving the corporation in 1913, Mr. Wendell has been acting in a general consulting capacity. Beginning July 1, Mr. Wendell will visit several eastern stations of the bureau and will advise frequently with officials of the bureau. At the University of Illinois, Urbana, Ill., research work is being carried on to assist the development of successful methods for cleaning



The Open Hearth

high sulphur coals, to render them suitable for coke and gas making, and in this work Mr. Wendell will assist.

V V

William S. Fisher, St. John, N. B., who was recently elected president of the Canadian Manufacturers' Association, is president of the Enterprise Foundry Company, Sackville, and vice president of Emerson & Fisher, Ltd., St. John. He was president of the St. John Hardware Association in 1907, and president of the St. John Board of Trade in 1896 and 1897, and president of the maritime branch of the Canadian Manufacturers' Association from 1914 to 1918. In 1918 he was called upon by the war purchasing commission to take charge of the outfitting of the first construction battalion in France, and in April, 1919, the Canadian government appointed him commissioner in charge of the Dominion rifle plant at Quebec.

V V

Donald P. Hess was recently appointed general manager of the Columbus, O., plant of the Timken Roller Bearing Company, Canton, Ohio, succeeding C. N. Replogle, resigned. Mr. Hess has been connected with the Timken Roller Bearing Company at its Canton plant for three years.

V V

Stuart B. Marshall, consulting engineer and metallurgist of Washington, was recently elected president of the Virginia Military Institute alumni in Washington. Mr. Marshall was formerly general manager of the American Manganese Manufacturing Company, Dunbar, Pa., and general superintendent of the Aluminum Company of America business in North Carolina.

V V

A. Bowman, formerly in charge of the Lebanon, Pa., yard of Luria Bros. & Co., Lebanon, scrap dealers, is to take charge of a new yard soon to be opened by the company at North Side, Pittsburgh.

V V

N. Julien Thompson has left the employ of the State of Connecticut Industrial Waste Commission, and will be retained by the Standard Rolling Mills Company of Springdale, Conn., as engineer, in charge of development work on a by-product lithopone plant.

H. H. Barker, formerly chief chemist and plant manager of the Ore Products Corporation, Denver, Col., is now chief chemist of Corning & Co., Albany, N. Y.

V V

The Society for the Promotion of Engineering Education has elected the following officers for the ensuing year: President, Charles F. Scott, Yale University; vice presidents, H. J. Hughes, Harvard University, and E. J. McCaustland, University of Missouri; secretary, F. L. Bishop, University of Pittsburgh; treasurer, W. O. Wiley, New York City. The following are members of the Council: P. H. Daggett, University of North Carolina; J. H. Dunlap, University of Iowa; M. L. Enger, University of Illinois; J. C. L. Fish, Leland Stanford University; F. E. Gieseke, University of Texas; Morris Knowles, Pittsburgh, Pa., and O. M. Leland, University of Minnesota.

V V

W. W. Odell, fuels engineer of the Bureau of Mines, is now in North Dakota, where he will coöperate with Prof. Babcock of the University of North Dakota on an extended series of tests of lignite carbonization. The experimental work will be done in the small lignite coking plant of the University as a portion of the coöperative work of the Bureau of Mines and the University.

V V

Peter Eyermann, who was connected with steel work in Austria during the war and since the armistice has been manager of the Bohemian State Steel Works, was recently appointed manager of the Austrian arsenal at Vienna. Mr. Eyermann was engaged in steel work engineering in the United States about 20 years ago, particularly in connection with the introduction of the blast furnace gas engine. Later he had offices at DuBois, Pa. On going to Europe some years ago, he was connected for a time with the steel works at Witkowitz, Austria.

V V

F. E. Norris, formerly general superintendent of the Sharon and Farrell works of the Carnegie Steel Company, is expected to return from France about August 1st, where he has resided for two years. Mr. Norris has been supervising construction of an open-hearth plant and rolling mills for the M. Berliot Automobile Company, near Lyons, France. It is understood the company has abandoned plans for additional work after about half completing its plant.

Some Pointers on By-Product Coke Oven Operations

THE MANUFACTURE OF ALCOHOL FROM COKE OVEN GAS.

By C. F. Tidman.

PART II.

To give surface alone, special packing material was used at Skinningrove in plant experimental towers, but although a large surface was provided, allowing three minutes' contact, 80 to 90 per cent absorption of the ethylene was not obtained.

Keeping in mind these facts, a series of experiments was carried out in a flask of 1950 cc capacity filled with dry desulphurized coke-oven gas. The flask was heated in a water bath until the temperature of the gas was about 80 degrees C., hot acid (300 cc) was added and the flask covered with a non-conducting material and vigorously agitated, to afford adequate surface contact, for periods varying from ½ to 3 minutes. Further experiments were carried out using 5 per cent of silica with the 95.4 per cent sulphuric acid. The results obtained are shown in Fig. 2, from which it is seen that the addition of silica increases the absorption by approximately 5 per cent. The function of the silica is not quite clear, but it appears to have a catalytic action and not merely a surface effect, since during the first few experiments on the small laboratory towers the absorption was particularly good, while a much later experiment, using the same towers, showed a falling off in percentage absorption. conditions remaining exactly the same except that the silica packing was coated with a slime of lead sulphate. In the experiments just described the addition of silica greatly increased the amount of froth formed on the surface of the acid, thus giving much better contact between gas and acid.

From the figures quoted it will be seen that for three minutes' contact by either method—towers or direct agitation in flask—the percentage absorption is 90 per cent, so that whichever method of scrubbing is finally adopted—i. e., towers or mechanical washer—it should be possible to remove 70 to 80 per cent of the ethylene by allowing 2½ to 3 minutes' contact.

Spraying the acid into the gas has also been tried, but difficulties occurred in maintaining the required temperature and also in blocking of the sprays. It was decided that this type of scrubber was not suitable. However, certain forms of mechanical washers give practically the spray effect without the disadvantages of blocking of small jets as used in sprays.

The next point to be determined is how nearly sulphuric acid can be saturated with ethylene before it will cease to act as an efficient absorber. Mr. Bury stated that 18 per cent of the acid radicle is available for ethylene absorption, i. e., 95 per cent sulphuric acid (R. O. V.) would continue to absorb ethylene until reduced to 77 per cent H_2SO_4. We have since found, however, that acid already saturated 18 per cent would still continue to absorb ethylene in a mechanical agitator, 30 per cent of the ethylene present being absorbed in 2½ minutes.

A mechanical washer would have the advantage over a tower scrubber system in that the size of the plant would be much reduced, and the power required to drive such washers is not great, considering the power required for pumping and the inconvenience of periodically cleaning a tower scrubber. The absorption product contains free alcohol in addition to sulphuric acid, ethyl hyrdogen sulphate, and diethyl sulphate. This was apparent from the results of a trial run on the experimental plant. From analyses of the gases from each scrubber it was seen that No. 1 scrubber gave a shortage when distilled for alcohol, but scrubbers 3 and 4 each yielded more alcohol than was indicated by the gas test. In a number of tests the free alcohol has been as high as 50 per cent of the total yield. It was therefore, decided to recover the alcohol by distillation under reduced pressure, first allowing distillation to proceed without steam, and admitting steam when the temperature of distillation increased so that the speed of distillation was maintained. The following figures indicate the procedure. The acid was first diluted to 64 per cent H_2SO_4 by the addition of water. Under a vacuum of 26½ inches, distillation commenced at 94 degrees C., the highest temperature recorded being 146 degrees. The alcohol distilled over satisfactorily, and no frothing took place. The finished acid, which was free from alcohol, free or combined, showed 80 per cent H_2SO_4

The method suggested earlier for recovery of the alcohol was to use a counter-current flow of acid and superheated steam. Over short periods, this method was satisfactory, but after a time large amounts of froth were produced, which passed into the condensing system.

The bulk of the alcohol obtained from this process is in the form of a 15 per cent distillate, any weaker distillate obtained being used for diluting the acid to the strength required for distillation in vacuo. The production of strong alcohol from this weak distillate is hardly within the scope of this paper, since the distillate is of a very similar strength to that obtained by fermentation. The alcohol itself, however, is very interesting in view of the impurities present. These are not important when the alcohol is to be used as fuel, since the alcohol burns completely—indeed, it has been considered possible that the revenue authorities may even accept the spirit as sufficiently denatured to pass into use without the addition of other substances; certainly the crude spirit is much less potable than methylated spirit. The alcohol, however, possesses an objectionable odor, which persists in other products made from it. For example, chloroform made from by-product alcohol was reported to satisfy B. P. requirements only after treatment with hot concentrated sulphuric acid to destroy the odorous substances, the washing process reducing the bulk 10 per cent. In preparing strong alcohol from the weak distillate it had been noted that the weak distillate was often cloudy, but became clear on heating, showing that the substance present was more soluble in hot than in cold alcohol. Repeated distillations from the 80 per cent alcohol left a residue which on cooling deposited a white, crystalline solid, which was found to be diethylene dissulphide (mp 111 degrees C., uncorr.). In addition to this impurity a yellow oil containing about 15 per cent of sulphur was found on the surface of the weak distillate. Both forms of impurity were present in largest amount in the first scrubber. Since only a small quantity of the oil is available and it has a wide range of boiling point, it has not been possible to fix definitely the exact substance present. A further difficulty in that diethylene disulphide is very soluble in this oil and consequently it is difficult to obtain the oil free from this substance.

TRADE NOTES

Removal of its Pittsburgh offices from 940 Oliver Building to 647-648 Oliver Building, has been announced by the American Manganese Manufacturing Company, Philadelphia.

Announcement has been made of the appointment of F. E. L. Whitesell as New England representative of the Railway & Industrial Engineering Company, Greensburg, Pa., with offices at 136 Federal street, Boston.

The Pawling & Harnischfeger Company, Milwaukee, has moved its San Francisco offices from the Monadnock Building to 32 Beale street, where a show room and stock are being maintained.

The Link-Belt Company, Chicago, has acquired all of the capital stock of the H. W. Caldwell & Son Co., and Frank C. Caldwell has been elected a director of the Link-Belt Company. The Link-Belt Company has thus added two new lines, helicoid conveyors and power transmission machinery, to its present line of manufacture. The H. W. Caldwell & Son Co.'s plant will continue to operate under separate corporate existence and under its present name.

The Combustion Engineering Corporation, New York City, announces that the sales organization in Philadelphia has been increased and a new service department inaugurated, which has necessitated getting new office space. Its new location is on the tenth floor of the Finance Building. The territory is under the management of W. C. Stripe.

The Electric Furnace Construction Company, Philadelphia, Pa., announces that the Compania Electro Metallurgia Braziliera and the Batcheller-McConnel Company, New York City, have recently acquired from Frank Hodson, president of the company, and his Swedish associates the exclusive rights and licenses for Brazil for the Gronwall type "Electrometall" electric shaft smelting furnace. Two large furnaces, each of 3,000-kw capaciyt, are at present being installed by the Brazilian company.

The Metal & Thermit Corporation, New York City, has recently transferred William Aldrich from the Southern territory to the Western territory. He will travel extensively through California, Oregon, Washington, Idaho, Nevada, Utah and Arizona, and will make his headquarters at the new South San Francisco office. William H. Moore, who until recently was assigned to the Chicago territory, now has charge of the Southern territory. This company also announces that in order to handle more satisfactorily its detinning business in the West it has constructed and will shortly place in operation in South San Francisco, Cal., a large new plant for the production of detinned billets, in addition to the detinning plants already operated at Chrome, N. J., and East Chicago, Ind. This new plant has been equipped with a large welding shop containing equipment and facilities for undertaking repairing by the Thermit process.

The Terminal Engineering Co., New York City, has added to its staff J. F. McGonigal, formerly of the Foamite Co., and J. H. Potter, a graduate of New York University. M. E. Lyle, for many years with the Columbia Graphophone Company, has been elected a vice president and is direclty responsible for new business, and M. E. Peck has been elected secretary and assistant treasurer.

The Allied Machinery Company of America, 51 Chambers street, New York City, have been appointed foreign representatives in all countries except the United States and Canada for the Universal Crane Company.

H. J. Freyn, president, Freyn, Brassert & Co., Chicago, Ill., sailed for Europe on an extended business trip through England, Belgium, Holland, France and other countries. Mr. Freyn is expected to return in October.

TRADE PUBLICATIONS

The fourth edition of the A. B. C. of Iron and Steel has been issued by the Penton Publishing Company. This book describes accurately and completely, but in a simple, interesting, and non-technical way, every step in the manufacture of iron and steel from the ore to the finished product. It is not intended for the technical specialist, but for the busy, practical man who wants to have a broad, general knowledge of the whole iron and steel industry. From the top of the first page to the bottom of the last, there isn't a sentence that needs explanation, and, to make everything doubly clear and understandable, over two hundred photographs of iron and steel mill operations and equipment have been included.

The Link-Belt Company of Chicago, Indianapolis, and Philadelphia have just issued a new Steel Chain Data Book No. 475. In this book is presented completely the heavier rugged steel chains used for power transmission, and also including elevating and conveying chains.

The Chicago Pneumatic Tool Company, New York City, has issued Bulletin 648, which describes little giant geared air hoists, motors and winches. This bulletin shows application views of this hoist in various industries and for innumerable operations, such as handling steel plates in storage yards, serving sheet steel to cutting machine at large boiler shops, etc. Copies will be sent to those interested, upon request.

The Draper Manufacturing Company, Cleveland, Ohio, has issued a very attractive catalog, No. 7, entitled "Steel Barrels for All Purposes." The first section illustrates and describes the various types of steel barrels and gives their capacity, dimensions, cubic space, weight and average number to car load. The Interstate Commerce Commission tests to which these barrels were subjected are explained. Pages 103 to 160 contain useful tables not ordinarily found in a catalog of this type. This feature makes the booklet of unique value.

The Pawling & Harnischfeger Company, Milwaukee, Wis., has issued two new leaflets, on shovel attachment for P. & H. types 205 and 206 excavator-cranes.

Carrier Air Conditions Company of America, Buffalo, N. Y., has issued Catalog 480, on "Carrier Air Washers and Humidifiers," which is well illustrated.

The Sullivan Machinery Co., Chicago, Ill., has just issued Bulletin 78-A, which describes and illustrates dry vacuum pumps, single cylinder, steam and belt driven. These pumps are equipped with improved water type plate valves for both intake and discharge openings. The Sullivan turbinair hoist is another new product, which is described in Bulletin 76. These hoists are used in mining of coal and metal and in many phases of industrial work.

The Wheeler Condenser & Engineering Co., Carteret, N. J., announces the publication for the 1921 edition of its "Steam Tables for Condenser Work." This is the sixth edition. The tables are in book form, pocket size. The properties of saturated steam are tabulated from 29.8 inches vacuum to atmospheric pressure in increments of tenths of an inch referred to a 30-inch barometer. The values were especially calculated for this book by Prof. Marks. As it is customary in vacuum work to read vacuum in inches of mercury, this is superior to the old method of giving absolute pressures in pounds per square inch. Above atmospheric pressure the increments are in pounds gauge. The book explains how measurements are made by means of the mercury column and barometer, and gives constants and tables for making corrections. Corrections for the thermal expansion of mercury, for the relative expansion of mercury and brass scale, and other corrections are included.

COMING MEETINGS AND EVENTS

American Ceramic Society's summer meeting will be held at Canton, Alliance, Sebring and East Liverpol, Ohio, July 25 to 27. Headquarters will be at the Hotel Courtland, Canton, Ohio.

American Chemical Society, the Society of Chemical Industry and the American Section of the latter society will hold a joint meeting in New York, September 6 to 10.

American Elecetrochemical Society will hold its fall meeting in Lake Placid, N. Y., September 29 and 30, and October 1.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., SEPTEMBER, 1921 No. 9

Discussion on Open Hearth Practice

Segregation In Basic Open Hearth Steel—The Effect of the Acid Slag in Causing Segregation Is Shown by a Series of Tables.

By **HENRY WILLIAM SELDON**, B.S., Met.Eng.,
See-Seldon and Associates, Engineers.

THE claim department of the steel mill is not interested in the good steel the mill is making, but, rather, in the bad. If one were to form his impression entirely from the information available in the claim department he would be inclined to question if the company made any good steel at all. When the steel is satisfactory to the customer nothing is said, but let the customer have trouble with the steel and a complaint is lodged at once. It is also surprising how the condition of the times influence the customers' claims. When times are booming and steel is hard to get the customer is apparently not so particular and the claims are proportionately low. However, as times get harder and more steel is available, the proportion of claims at once increase.

In some cases the customer himself is at fault, either through lack of knowledge in ordering his steel, or in his manufacturing methods, but in many other cases the steel manufacturer is at fault. Among the numerous causes for the steel manufacturers' troubles may be cited segregation, piping, burned steel, slaggy steel, mixed steel, and various forms of surface defects caused by heating and rolling operations.

Table No. 1

ANALYSIS OF SLAG

Sample	Heat No.	Remarks	Fe. Iron	$SI O_2$ Silica	AL_2O_3 Alumina	$CA O$ Lime	$Mg O$ Magnesia	P_2O_5 Phos. Anhydride	Mn. Manganese
1	A.	Bath before tapping.	11.04	19.90	4.29	45.40	9.44	4.69	2.02
2	A.	On top ladle........	7.46	25.34	4.39	40.90	6.45	3.11	8.00
3	A.	After casting slag in ladle	4.65	27.50	8.24	35.50	6.70	2.16	10.86
4	B.	Bath	11.72	20.16	3.06	42.90	9.68	4.60	1.87
5	B.	Top ladle	5.23	26.62	6.61	42.60	7.68	2.84	5.26
6	B.	After	2.40	34.00	8.48	34 40	6.00	.46	10.73
7	C.	Bath	9.78	19.90	3.83	46.20	8.99	5.70	1.66
8	C.	Top ladle	4.94	34.00	7.15	28.20	6.12	1.79	2.92
9	C.	After	3.10	33 30	7.40	28.30	6.12	.27	15.27
10	D.	Bath	10.85	19.40	3.16	45 80	8.66	5.83	1.66
11	D.	Top ladle	6.78	25.50	5.21	40.90	8.15	4.51	5.62
12	D.	After	4.46	30.30	6.62	36.00	7.32	2.91	8.79

There has been and always will be controversy between the manufacturer and customer as to what constitutes injurious segregation. We will not attempt to take sides, but give the following analysis and remarks for their beneficial value only. We might add, however, there is a big opportunity for improvement on the part of the manufacturers with regards to both the quality and quantity of the steel being produced.

In the manufacture of 40 to 50 carbon steel many steel men have at times found considerable variation in the analysis between the ladle test and the last ingots of certain heats. The carbon and phosphorous showing the greatest variation with sulphur follow the same tendency. This condition was particularly noticeable in heats when large additions of ferro silicon had been added in the ladle.

In the special case being cited it was found that these large additions were making the slag in the ladle acid, particularly while the last ingots were being poured. It was found this segregation was practically eliminated by adding four shovelfuls of burnt lime to the ladle just before it was full.

The effect of the acid slag in causing segregation in the ladle is shown by the analysis of slag and steel in tables No. 1 and No. 2.

Likewise in certain structural heats in which coal was used in the ladle it was noted that the last ingots were higher in carbon than the ladle test. This was found to be caused by some of the coal being held by the slag and not dissolved in the steel until the last of the heat was being poured. This condition was corrected by running slag off the ladle while tapping.

Steel making in America has now reached the stage where poor and indifferent practice will no longer be tolerated.

Table No. 2

ANALYSIS OF STEEL

Heat No.	Test	Carbon	Silicon	Phos.	Sulphur	Mang.
A.	Ladle test.	.43	.16	.030	.035	.60
A.	Bot. ladle.	.51	.12	.045	.039	.60
B.	Ladle test.	.42	.12	.039	.037	.60
B.	Bot. ladle.	.48	11	.056	.042	.58
C.	Ladle test.	.45	.13	.022	.031	.73
C.	Bot ladle.	.59	.13	.047	.042	.76
D.	Ladle test.	.44	.14	.020	.029	.72
D.	Bot. ladle.	.53	.12	.042	035	.72

Detroit Steel Casting Company Plant

A General Description of a Most Modern Steel Casting Plant—Improvements Have Recently Been Completed Which Modernize the Equipment of This Plant to the Very Greatest Extent.

By H. M. LANE.

MANY of the foundries in this country have rather a short history and can only point to work under a certain management, in some cases only for a limited length of time; but the Detroit Steel Casting Company is one which has helped make history in the steel business. Originally it was a small converter shop with one Roberts converter, but as time passed the business increased and some relatively small open hearths were added. From time to time the open-hearth equipment has been increased and the converter equipment increased and improved.

A general plan of the plant as it now exists shows that there are practically two foundries, the No. 1 shop being an open-hearth plant used mostly for the production of fairly heavy castings, and the No. 2 shop a converter unit for the production of small castings.

All of the cores for both departments are made in the coreroom shown and the dry sand molds either in the main bay of the No. 1 shop or in the side bay. They are dried in the ovens. The converter work is practically all done in green sand.

The raw materials enter the yard on the company's switch, the cars being spotted on a long track along the side of the foundry. All subsequent switching is done by the company's locomotive crane, which also does a large portion of the unloading. The sand mixing and preparation department is located between the core-room and the open-hearth melting unit and is so arranged as to reduce handling as much as possible.

Beginning with the core department we encounter a department with quite a history back of it. Formerly the cores were made in another part of the plant, occupying a space nearly twice as great as the present coreroom, and with several times the number of cubic feet of ovens. When first installed they were operated on the coke-fired forced-draft principle. Under ordinary circumstances the whole battery is heated from one firing system. This battery was one of the early installations of the Lane patent forced-draft auxiliary-air type ovens, which are now manufactured by Holcroft & Co., of Detroit, and was installed just before the war broke out. It fulfilled the requirements of the plant very nicely, but soon after the country went to war the demand for truck castings multiplied manyfold, and it became necessary to organize the coreroom so as to get maximum output. The three small rack type ovens at the right of the illustration, for many months in succession, baked an average of thirty-two cars of cores every twenty-four hours, and the larger oven either baked large cars or two racks at a time. The coreroom is covered with a traveling crane, and the core racks are placed between the coremakers' benches, as shown in Fig. 1, the coremakers placing the cores directly on the racks. The crane then picks up the rack and places it on the cars in front of the ovens. The car is run into the oven, the cores baked, the car run out and the rack of baked cores transferred by the crane to the core storage department. In some cases it is handled by a transfer car and sent directly to the folders' floor.

After these ovens had been in use for several years they were equipped with a specially designed stoker for burning soft coal. This is known as the Hare stoker and is now manufactured by the Hare Stoker & Furnace Co. of Detroit. The change from coke to stoker-firing resulted in drying the cores with fewer pounds of fuel than formerly, and with a fuel which costs less than half as much per ton. It also eliminated a large proportion of the labor of firing the ovens, as the stoker has an automatic cleaning feature.

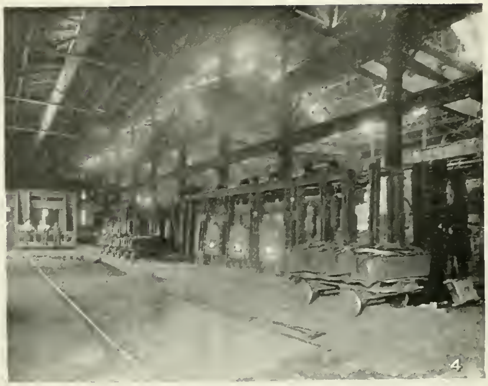
Particular attention is called to the type of coremakers' benches shown in Fig. 1. Between each two rows of benches there is a narrow sand alley, and a man wheels the sand in behind the benches and delivers it to the coremakers without interfering with their work. This room with its present arrangement has proved a splendid unit for the intensive production of foundry cores, and when the size of the coreroom and the size of the foundry are compared one will readily appreciate the fact that it must be an efficient department to take care of the entire plant.

The dry sand fold department as at present constituted is equipped with one wide oven and two narrow ovens, as shown in Fig. 2. The wide oven at the right has two parallel tracks and either takes two trains of narrow cars or the cars are bound together by a special device and large molds put on. The narrow mold oven at the left is made deeper than the others, so that it will handle locomotive frames.

These ovens are all fired from two fireboxes in a pit under the cleaning room floor back of the mold ovens. An interior view of this pit is shown in Fig. 3. This is a forced draft type pit, the air coming down through the pipe shown in the upper right-hand corner of the ceiling, the auxiliary air entering the walls about the furnaces through the small square openings shown in the brick wall at the right and left of the ovens. The air for combustion passes in through the ashpit door and is controlled by blocking the door open to any desired degree. This style of forced draft auxiliary air firepit is practcially the same as was used on the core ovens before the stoker was installed, and it is the intention now to replace these fireboxes with stokers at some time in the future. The present installation, however, has been in use for a number of years, and the construction of these boxes with their aid the cooling system gives a very long life to the brick work, as well as a great fuel economy in the oven.

The converter department is an independent unit in all respects. It has its own annealing oven and its own cleaning department, and this tends to keep the two classes of castings separate. The cleaning department adjoins the side of the No. 2 shop.

The bank of closets adjoining the wash room at the end of No. 2 shop are suspended in such a way that molding goes on underneath them.



The melting unit in the open-hearth department consists of two 20-ton furnaces as shown in Fig. 4, which were built by Holcroft & Co. This illustration shows the charging platform side of these furnaces. The furnaces originally installed at the Detroit Steel Casting Company's plant were lower, and when the two furnaces were repaired the charging platform was raised above the molding floor line. A charging machine was installed as shown, and a handling scheme for handling the scrap in the yard, making up the charges and delivering carloads of charging boxes to the charging platform. One of these furnaces was originally operated by produced gas, and the producers are still installed, so that they can be used at any time. The other furnace has always operated on liquid fuel. At one time some years ago, when fuel oil was very high and tar cheap, this furnace was run on coal tar a considerable period with very satisfactory results, but oil is simpler to handle, and at many times the market is such that tar cannot be obtained so as to compete with the oil. At present the melting is being conducted with oil.

The main bay of the foundry is equipped with a number of traveling cranes of various sizes which enable them to handle any size casting which comes within the limits of their pouring ability.

Fig. 4 shows one of the main bay cranes over the oven roof.

A general view of a portion of the main bay of the open-hearth foundry is shown in Fig. 5. This view also illustrates a method of skidding molds which is commonly used in this plant. Two pieces of railroad iron are clamped together with suitable spacers and provided with links at the end. Upon these are piled the molds as they come from the molding machine. The entire skid is then taken to the pouring floor, where it is shown in this illustration. After pouring the skid of molds is taken to the shake-out floor, and later the skid with the empty flasks and bottom boards on it is returned to a position near the molding fachine. In this illustration the melting unit is on the right and the dry sand molding department on the left.

The very large castings are cleaned under the main cranes in the No. 1 shop, and a large annealing oven is located under this crane, where large castings can be annealed. The smaller open-hearth castings are cleaned in either one or two cleaning departments. One, which is mostly devoted to railroad work, is located in the same side bay that contains the coreroom and the molding units, and the other, devoted mostly to jobbing castings, is located in the opposite side bay adjoining the dry sand ovens. The castings from these two departments are shipped at the end of the building. Practically all small castings that are to be shipped in carload lots are cleaned in the bay adjoining the felting unit, and provision is made for switching a car into this department under the crane. Provision is also made for shifting a car into the main bay of No. 1 shop and loading heavy castings. The product of the other cleaning room is practically all trucked to local customers.

At the end of the plant adjoining the annealing furnace there is a sand conveyor pit and refuse hoppers on the outside arranged to take care of outgoing sand and to recover a portion of this for reuse in the plant.

There are a series of grinders in the cleaning departments. In the case of the large swinging grinders the castings are generally mounted on a wooden frame carried on rollers, and the workman rides on this frame and moves the casting back and forth under the wheel as he grinds it. This gives him thorough control of his work.

Fig. 6 shows a portion of the battery of saws and other tools used for cutting off heads and risers in one of the cleaning rooms. In this illustration attention is called to the charging box standing in the foreground. These charging boxes are placed at intervals through the cleaning department, and all heads and smaller waste material thrown into them, care being taken to see that each grade of material is kept by itself. These boxes are then transferred by the crane to a car at the end of the shop and by it transferred to the metal department adjoining the open-hearth building.

Attention is called to a number of features in connection with this plant which have been developed for the advantageous handling of the property. The pattern shop and main pattern vault are located in a separate building adjoining the No. 2 shop, and yet at the same time in such a position that these patterns are readily accessible to the molders on either of the molding floors. An auxiliary pattern storage for outside patterns and patterns that are rarely used is located at the opposite end of the plant.

As already stated, fuel oil is used, and for the storage of this a double reinforced concrete tank has been installed near the track entrance to the yard, and this tank holds 180,000 gallons of oil. This tank is designed to carry 10 to 12 feet of coal piled on top of it.

The plant formerly had its own power plant, but at present the boilers are used only for heating purposes, and the electric current is obtained from the Detroit Edison Company.

For the last few years the H. M. Lane Company has acted as the engineers for the Detroit Steel Casting Company, designing certain special equipment for them and collaborating with them in carrying out the various improvements and extensions which have been necessary.

PITTSBURGH CHAPTER OF THE AMERICAN SOCIETY FOR STEEL TREATING

On August 23, what was termed the Council of the Pittsburgh Chapter of the American Society for Steel Treating, met at dinner at the Hotel Chatham for the purpose of discussing plans for the coming year. This Council was made up of about 20 including the various officers and members of committees. Dr. C. M. Johnson, recently elected chairman of the Chapter is ambitious to make it the biggest year the Pittsburgh Chapter has ever known and accordingly has been holding various committee meetings to complete arrangements. It was decided that the entertainment committee should provide some special entertainment feature for each regular meeting.

An unusually prominent and interesting group of speakers has been secured for the coming meetings which will be held on the first Tuesday of each month. At the first meeting, September 6, Prof. F. F. MacIntosh of Carnegie Institute of Technology will speak on "The Metallury of Iron and Steel." This meeting will be in the Hotel Chatham and will be preceded by a dinner at 6:30 and the special entertainment feature mentioned above. It is requested that any one desiring to attend the dinner, remit to Mr. D. W. McDowell, secretary-treasurer, 203 Conniston Avenue, Pittsburgh, Pa., a check for $1.50.

The October meeting will be addressed by Mr. Chas. E. Carpenter, president of the E. F. Houghton Company, a speaker who is nationally known. His subject will be "Individualism vs Socialism." In November, Prof. Albert Sauveur of Harvard will speak on the Heat Treatment of Steel. In December, Prof. H. F. Moore of the University of Illinois will discuss Fatigue Testing and Resistance of Materials.

U. S. Government Air Nitrate Plant No. 2 Muscle Shoals, Ala.

War and Peace Time Purposes of Its Construction—Future Limitations as a Competitor of the By-Product Plant as a Producer of Ammonium Nitrate for Fertilizer or Explosives.

By GEO. B. CRAMP.

A SUBJECT under this headline might appear somewhat out of place in these columns were it not for the growing interest of Blast Furnace and By-Product Coke plant operators and technicians in the subject of commercial farm fertilizer production as side lines or by-products of their basic operations.

It is not widely known that, at blast furnaces located in certain localities where high phosphorous ores are mostly available, a by-product of their operation is their high phosphorous slag which with but little treatment is made available as a phosphate fertilizer.

At other furnace plants where ores high in potash are mostly used, a rich return is realized in the recovery of potash, which is readily separated from the blast furnace dust carried out of the furnace by the gases. It is the possibilities along these lines that have given such impetus to development of the electric dust precipitators, descriptions of which have appeared from time to time in this periodical.

Blast furnace gas itself is composed of a high percentage of nitrogen, but it is not in such combination with hydrogen that it forms ammonia which would in turn render its recovery possible. It is highly improbable, however, that nitrogen will ever be recovered from blast furnace gas, at least on an economic or commercial basis; but the inability to produce nitrogen at the blast furnace is more than compensated for by the by-product coke plant, which in good blast furnace practice today may be considered an essential adjunct.

Not all blast furnaces produce either phosphate or potash, but all by-product plants usually produce nitrogen in the form of ammonium sulphate. It may be generally stated, however, that the blast furnace and by-product plant together produce all these three elements necessary to plant growth, development and maturity.

Neither one of these elements alone is a balanced fertilizer; and all three are usually supplied in various proportions for different crop requirement, but in scientific crop management it is first determined by soil test which element is lacking, and which element is most needed in the production of the particular crop to be grown, and the requisite element then applied in proper amount.

One other consideration of soil conditions is necessary in the selection of fertilizers, namely, the determination of the acid or alkaline content. By use of litmus paper, soils are found to be either acid or alkaline; but if no discoloration of the paper is indicated the soil is in neutral condition, that is, the acid that may be present is neutralized by a sufficient amount of alkali so that neither show a predominance.

Some crops do well in acid soils and show poor results in soils too highly alkaline and vice-versa. This accounts for the general opinion that some crops do much better in certain parts of the country than in others where climatic conditions are equal. This idea is erroneous, however, as all things being equal, all crops do equally well under neutral soil conditions.

The soils of eastern, east central, and southern United States were acid in their virgin state because acids are given off in the decomposition of the vegetable matter which usually forms the top or surface soil in these sections. After some years of cultivation, the acid reaches out of the soil to such a degree that the lime stored up in the decayed vegetable would cause a reaction to the alkaline state. After continued cultivation this lime is exhausted and the soil reverts again to the acid state because of the acids produced by decomposing roots left in the ground after crops are removed or from any other vegetable decay.

The soils of western, northwestern and southwestern United States are usually alkaline in their virgin state and tend to remain so if not irrigated or influenced by applications of fertilizers of acid base and by continued crop culture.

The best soil conditions being the neutral state, acid soils may be brought to this condition by application of lime or fertilizers having a lime base, while alkaline soils are best neutralized by applications of acid fertilizers and by growth and turning under of green crops which form acid in decomposition.

In the growth of all crops large amounts of nitrogen are required. As most commercial nitrogen fertilizers are acid in their ultimate influence on the soil, they are well adopted to ailkaline soils such as predominate in western United States; but where these acid base fertilizers are applied to acid soils such as predominate in eastern United States, they simply add to the natural acid tendency of these soils, making frequent applications of lime necessary to maintain neutral soil conditions. From this it will be seen that the application of nitrogen fertilizer, with a lime base, to an acid soil would at once add the desired fertilizing and neutralizing elements and avoid overburdening the soil with excess acidity.

Such a lime – nitrogen fertilizer, called Cyanamid was being manufactured before the late war by the American Cyanamid Company of New York City with a plant at Niagara Falls, New York, where hydro-electric power entering largely into the process, is obtained at the lowest rates.

This company operated under a patented process originating with Scandinavian interests, where the process has proven a commercial success due to low hydro-electric power costs, and no competition from by-product fertilizers. The main source of nitrogen fertilizer supply before the war was Chilean sodium nitrate, or saltpeter, of which there are large but limited supplies in that country. During the war practically all imports of this nitrate went into the production of high explosives, one of which was the much mentioned T. N. T. or triple nitrated toluol.

As the United States government had neither influence nor control over any part of the Chilean nitrate supply, and as it was desirable to release all shipping possible, for cross sea service, it was finally decided to build a nitrate plant which would help solve the shipping problem and at the same time make this country entirely independent of all outside sources of nitrate supply.

The process selected was the above mentioned Cyanamid Process. A corporation called the Air Nitrate Corporation, a branch of the American Cyanamid Company, was organized under government supervision to build a large plant at Muscle Shoals near Sheffield in northwestern Alabama on the Tennessee river, where there is eventually to be built a large dam across the river and a hydro-electric plant, by the government. As an emergency measure, however, a large steam power plant was built in connection with the Air Nitrate Plant to immediately supply the requisite electric energy.

Besides being able to turn out large quantities of ammonium nitrate for war use, by adoption of the Cyanamid Process it would be relatively easy to convert the plant in peace time to fertilizer manufacture, and as both lime and acid-base nitrogen agricultural needs could be met, and at a supposedly low cost considering the cheap labor, and raw material costs and eventual low hydro-electric power costs, which the location of the plant made accessible, while nitrogen, so important to the process, is secured from the atmosphere; but in this respect no particular location has any advantage over another.

Without attempting to go into costs of producing ammonia or nitrogen fertilizers by the Air Nitrates Cyanamid Process compared to the By-Product Process, an outline descriptive of each process will here be given, followed by a brief discussion as to future possibilities of the latter process as a cheaper source of both peace time fertilizer, or war time explosive production.

Cyanamid Process—Carbide Material Department.

The first step in the production of Cyanamid is to produce calcium-carbide; the identical commercial product used in the generation of acetylene gas used in illuminating systems, and in welding processes.

In making carbide, limestone of good quality and high carbon coke are received at a raw materials building where they are stored in bins and fed to conveyors. The limestone is conveyed to large rotary kilns where it is burned to quick lime which is the same commercial product used in mortar and plaster in building construction. The fuel used in this operation is powdered coal.

The coke is conveyed to rotary driers where all moisture is driven off. The quick lime and coke are then conveyed to storage bins awaiting use in the following process.

Carbide Furnace Department.

In this department, lime and coke are burned in a stationary (non-tilting) open top electric furnace, the result of the operation being calcium carbide.

Lime and coke are conveyed from the storage bins, and after being mixed in proper proportion are conveyed to small bins over the charging floor at each electric furnace. The mixture is gradually fed into the furnace from the charging floor by hand.

Under the influence of the pure and intense heat of the electric arcs of the electrodes, which are suspended in the center of the open top furnace, the lime combines with the coke forming a molten mass giving off carbon monoxide, which burns as it leaves the molten materials, and passes off as carbon dioxide. The chemical reaction taking place in the furnace is

$$C_2O + 3C + heat = C_2C_2 + CO.$$

When sufficient molten material is available the furnace is tapped at the side near the bottom through a hole which remains plugged with the chilled carbide material. Tapping is accomplished by burning or melting this carbide to a molten consistency when it will flow out of the tap hole permitting the molten bath, back of it, to flow out into cast iron boxes on cars called chill cars.

The chill cars with the hot carbide are delivered to the cooling room of the Carbide Mill Department the next department in order of the sequence of operation.

The Carbide Furnace Department is equipped with an electrode repair shop where the carbon electrodes for the carbide furnaces, are prepared and fitted with water cooled holding clamps. The electrodes are assembled three in a group. Wire netting is placed about each electrode and covered with a layer of heat resisting material. The electrodes are then set into a semi-muffle type heating furnace—coal fired—and the protective coating baked on under slow heat.

Carbide Mill Department.

Here the cooled carbide blocks or pigs are removed, after cooling, from the chill car boxes, and crushed in jaw crushes. After this operation the material is conveyed to ball mills where it is further reduced, and thence to tube mills—which are rotary cylinders containing rolling metal rods which accomplish the pulverizing of the carbide. The milling operations are conducted in an atmosphere of pure nitrogen secured from the Liquid Air Department to be described in turn. The nitrogen is piped under pressure into the mills thus displacing all air and avoiding explosion of acetylene gas which might form from contact of fine carbide dust with moisture of the air. Nitrogen uncombined being an inert—non-explosive—gas; the chance of such accidents are reduced to a minimum.

Nitrogen or Liquid Air Department.

Pure nitrogen gas being required in the foregoing operation and in even greater quantities in further operations of the process, this gas is supplied by the Liquid Air Process which begins with intaking air from the atmosphere and forcing it through scubbers for removal of solid and gaseous impurities. The air is then compressed to a pressure of 600 pounds per square inch and then by rapid expansion the moisture and liquified oxygen are fractionated from the remaining pure dry nitrogen which is piped to the various departments as needed.

Lime—Nitrogen or Cyanamid Department.

Nitrogen gas and milled carbide are combined, in this department, by the electric arc; the result being Cyanamid which must simply be milled to produce the commercial product. This is such a nitrogen fertilizer with a lime base as is referred to in the earlier part of this discussion on fertilizers.

In the operation of producing Cyanamid, cylindrical paper containers are set into vertical cylindrical ovens. These containers are filled with milled carbide by a traveling hopper car running over the ovens, in a similar manner to the method of charging coal into the coke oven.

Suspended through the center of the carbide is a thin carbon electrode with proper electrical connections, and after filling, the cover is fastened onto the oven and the electric current applied. When sufficiently heated, nitrogen gas is introduced into the oven through proper pipe connections and the absorbtion of nitrogen gas by the heating carbide begins to take place. One pound of nitrogen gas is thus absorbed by each four pounds of carbide used and the chemical reaction taking place is

$$Ca\ C_2 + heat = Ca\ C\ N_2 + C.$$

When absorbtion of nitrogen gas by the carbide has ceased to continue, the electric current and gas are turned off and the hot mass, which has solidified in the process, is removed in a cylindrical shape, and taken to the next department for milling.

Lime—Nitrogen Mill Department.

The cooling, crushing and milling of the lime nitrogen takes place here.

No great care is required in keeping the material dry while cooling as is necessary with carbide, nor is it necessary to mill this material in an atmosphere of nitrogen gas, as it does not readily combine with moisture to form acetylene gas.

Hydrating Department.

In this department powdered lime nitrogen from the mill department, has added and stirred into it just sufficient water to drive off the last traces of acetylene gas which may be generated from any free carbide that may chance to remain in the lime nitrogen.

From this department the hydrated lime nitrogen is conveyed to the ammonia gas department if it is to be converted to ammonia gas and ultimately ammonium nitrate, but the material as it leaves the hydrating department is refined commercial carbide or lime nitrogen fertilizer and is ready for shipment, sale and use as such.

If ammonium nitrate is to be produced from the cyanamid the process is continued.

Ammonia Gas Department.

Hydrated lime nitrogen is brought from the hydrating department to this department.

In a large vertical cylindrical vessel, called an autoclave partly filled with water, there is added in proper proportions, lime nitrogen and caustic soda. The openings are then tightly closed, and while the solution is being stirred, steam is introduced and the generation of ammonia gas begins.

After starting the reaction it generates its own heat. This reaction is

$$CaCN_2 + 3H_2O + heat = CaCO_3 + 2NH_3.$$

After all the ammonia available in the charge of lime nitrogen has been recovered, the remaining sludge and liquor are drawn off at the bottom of the autoclave, and run through rotary filters where the solid materials are separated from the liquor.

The liquor is pumped to storage reservoirs and used over again, and the slugs is pumped to some point or disposed of nearby.

Thus the coke and lime have simply served to absorb nitrogen gas until it is brought to this point in the process where it combines with hydrogen to form ammonia gas.

Nitric Acid Department.

About half of the total ammonia produced in the ammonia gas department is required for the production of nitric acid. In this process the ammonia gas is mixed with clean scrubbed air and the mixture passed through electrically heated platinum gauze catalyzers. By this means, ammonia is combined with air forming nitric oxide. This gas is carefully cooled—first in high temperature coolers, and then passes on to absorbtion towers where it is absorbed by water sprayed again and again through the towers until it has become 40 per cent nitric acid, and on reaching this strength is stored in tanks to be later used in the neutralizing process.

Nitrate Department.

Neutralizing the nitric acid from the foregoing operation is accomplished in this department by combination of the remaining ammonia gas—not used in production of nitric acid—with that acid, the result being a salt solution which is 45 per cent ammonium nitrate. This solution is then evaporated, crystallized and dried, after which it has the appearance of coarse salt. In this form it is shipped or use in the nitration of toheol, manufacture of other explosives, or as a powerful ammonia fertilizer of acid base.

General Comment.

Compared to the constructive by-product process of ammonia and other by-products removed the cyanamid ammonium nitrate process is destructive in that power and materials not originating from economic processes of manufacture, or as by-products of operation, are continually consumed to produce the ultimate product. In the by-product process new products result from each step in the process of cleaning the gas, of which there is a large surplus after fuel for ovens and power for plant operation is deducted.

It will be noted that in the production of carbide, coke is used. This same coke may have been produced in a beehive coke oven, in which case the valuable gas and other volatiles, including ammonia, have been lost, and after this serious loss it is used to absorb nitrogen again, a gas it once contained in easily recovered form, in its raw state, or as coal.

The coal that is used in this process for power and heating purposes also loses its valuable volatiles in combustion and but a small part of its total heat value finds its way into the product being manufactured.

An outline of the ammonia recovery process of the by-product plant follows.

By-Product—Processes of Ammonia Recovery.

In producing coke by this process, the coal is baked in an oven at a temperature sufficiently high to drive off the greater part of the gas and other volatiles which are properties of raw coal. The residue, after these gases have passed off, is carbon or coke. The gases and volatile are drawn from the ovens through tubular coolers in which the gas is brought to a temperature sufficiently low to bring down tar and some ammonia, which exists in weak liquor. The tar and weak ammonia liquor are mingled at first, but the two are readily separated in properly constructed tanks that automatically accomplish separation by gravity. The ammonia liquor is then run through a free still where the free ammonia gas existing in the liquor is driven off in vapor form, leaving certain solid deposits contained in the liquor, to form within the still. After the free ammonia has been released by heat, the remaining ammonia liquor is run through a fixed still where the ammonia gas is released by use of comparatively small quantities of lime water. The ammonia gas from both stills finally pass out a common outlet, and may then be condensed to form aqua ammonia, or be passed on to the saturator where ammonium sulphate is produced by the so-called direct process later described. The recovery of ammonia by distillation is known as the indirect process.

The direct recovery of ammonia is accomplished by passing the gas—after it has passed through the coolers—through a saturator in which the gas is caused to bubble through a bath of weak sulphuric acid solution. The ammonia, coming in contact with the acid, is neutralized and forms crystals which settle to the bottom of the saturator and are then removed and dried. This is commercial ammonium sulphate and may be sacked and shipped, for use as nitrogen fertilizer of acid base.

This form of nitrogen is produced so simply and inexpensively, compared to many other forms of manufactured nitrogen fertilizers, that it will doubtless be able to always compete favorably with, or undersell them.

It would be desirable if some of the ammonia, produced in sulphate form, could be combined with lime to form a nitrogen fertilizer of lime base as is done in the cyanamid process; but the same results may be obtained with acid base fertilizer on acid soils if the acidity is held in check by proper applications of cheap commercial lime, which practice will be less expensive than the use of the higher priced lime—nitrogen fertilizers.

Ammonium nitrate production by the by-product process, for use in explosives, is a future war time possibility, inasmuch as the large amount of ammonia gas produced by the indirect process is available for this purpose.

A possible arrangement for accomplishing this would be the installation of a nitric acid plant such as is described in the cyanamid process, at about half of the by-product plants, and at the remaining plants neutralizing and crystallizing plants might be installed. Ammonia gas from the stills would be converted to nitric acid at the nitric acid plants and the acid shipped to a plant having the neutralizing equipment. Here the gas from the stills would be combined with the nitric acid, then evaported, crystallized and dried—as in the ammonium nitrate process—the product being pure ammonium nitrate.

During the war this arrangement was not easily possible on a large scale as much of the present by-product plant capacity was not in existence and was rather widely scattered.

However, the rapid expansion of the by-product coke industry, which will, in the not far distant future, include all coke now produced by the beehive ovens, would put the by-product plants in a fair position to furnish large amounts of ammonium nitrate for explosive manufacture—in the event of a future war—and at a cost much less than, no doubt, by any other known and practicable process.

During the war successful efforts were made in the conversion of ammonium sulphate—as produced by the direct ammonia recovery process at the by-product plant—to ammonium nitrate. With some improvement yet to be made in the chemical purity of the product, the results obtained may be said to be satisfactory. With this process there is also a future possibility of turning the whole ammonia output of the by-product into ammonium nitrate.

Thus it may be possible through our by-product plant development to secure our country's entire independence of foreign sources of ammonia supply, in the future, or as long as our supply of raw coal shall last.

Incidentally the by-product plant would then produce the two principal components of tri nitro toheol, namely the ammonium nitrate and toheol requisite in its production; the by-product plant, even during the late war, having been the source of large supplies of toheol.

ELECTRICAL ENGINEERS' CONVENTION

The fifteenth annual convention of the Association of Iron and Steel Electrical Engineers will be held at the La Salle Hotel, Chicago, September 19-24, 1921. The sessions and exhibits will be held in the Municipal Pier.

Papers, particularly interesting to electrical engineers of steel plants will be presented. The authors of these papers are men who have devoted years to the study and operation of electrical applications and steel making processes; they are men well qualified to discuss the particular subjects allotted to them and are engineers known throughout the iron and steel industry.

The authors are as follows:

R. B. GERHARDT, Electrical Superintendent,
Bethlehem Steel Company, Sparrows Point, Md.

R. D. COUSINS, Electrical Engineer,
Illinois Steel Company, Gary, Indiana.

G. R. McDERMOTT, Assistant Engineer,
Illinois Steel Company, South Chicago, Ill.

W. N. FLANAGAN, Steam Engineer,
Ohio Works, Carnegie Steel Company, Youngstown, O.

F. B. CROSBY, Electrical Engineer,
Morgan Construction Company, Worcester, Mass.

A. C. BUNKER, Electrical Engineer,
Crocker Wheeler Company, Ampere, N. J.

A. M. MacCUTCHEON, Designing Engineer,
Reliance Electric & Engineering Co., of Cleveland, O.

E. T. MOORE, Electrical Engineer,
Halcomb Steel Company, Syracuse, N. Y.

F. W. CRAMER, Engineer of Tests,
Cambria Steel Company, Johnstown, Pa.

Papers will also be presented on the following subjects: Education, Standardization, Safety, Electrical Development in Steel Mills. The chairman of these respective committees will deliver these subjects.

In connection with the convention there will be also be the Exhibiting Feature.

Practically all the manufacturers of electrical products will be represented.

Analysis of Wholesale Electric Costs

Explanation of Rates and Methods of Reducing Power Costs to a Minimum.

By F. M. VAN DEVENTER.

ARTICLE III.

SYNOPSIS: *In the two preceding articles (June and July issues) graphic charts were presented, representing the Duquesne Light Company's schedule "F" and the West Penn Power Company's schedule "J" for wholesale power. The use of the charts for the purpose of checking power bills was demonstrated. In the present article, the "demand plus energy" system of rates upon which these schedules are based, is explained; and the use of the charts for the purpose of studying methods of reducing power costs is discussed.**

THE general economic principle upon which all rates for power and similar utilities are based embodies two principles—first, that the gross revenue from all consumers should cover all costs of producing the utility, including interest on the investment, insurance, taxes, depreciation, etc., plus a "fair" return in the way of profit on the investment; second, that the distribution of the gross cost should be such that the various consumers of the utility will pay for the service rendered them in proportion to their just part of the total cost.

The total cost of supplying a utility is composed of two classes of charges, namely the fixed and operating charges. For a given plant, the fixed charges are practically independent of the quantity of the utility produced, and include interest on the investment, insurance, taxes, depreciation and obsolescence, etc., which continue uniformly whether the plant is operating at full capacity or whether it is standing idle. The operating charges consist of the cost of raw materials, such as fuel, water, lubricants and chemicals, and also labor, repairs, etc. These, in a general way, vary in direct proportion to the quantity of production of the utility. This distinction between fixed and operating charges is just as important in the construction of utility rates as it is in the determination of the selling price of any commodity such as we buy daily in the open market, and its bearing on electric rates will appear in this analysis.

Systems of Rates.

Electric power rates may be considered in two different classes, namely, the "postal plan," and the "sliding scale" form of rate. The postal plan is the simplest form and was at one time in quite general use for all utilities and is still used almost exclusively for the sale of gas and water. Essentially the principle of the postal plan is that just as a two-cent stamp will deliver a letter a few blocks from the mailing point, or many hundred miles from that point for the same cost, so a kwh might be sold to all consumers at a definite fixed cost per kwh, regardless of the many and varied conditions which might be imposed upon the producing company in delivering this unit of energy.

This plan of selling electric power was very satisfactory a number of years ago, when the total power load consisted of incandescent lamps, and the various consumers used their lights during the same hours of the day, and no particular consumer was imposing any hardship upon the producing company any more than another consumer; hence it was logical to charge each consumer in proportion to the amount of energy which he consumed.

The postal plan of rates, however, has a number of very important shortcomings when applied to modern electrical loads, and on account of this fact the plan does not satisfy the second requirement of the general economic principle previously stated, inasmuch as it costs the utility company considerably more to deliver a kwh to some consumers than it costs to deliver another kwh to other consumers. The shortcomings of this plan prompted the development of the sliding scale type of rate. The various controlling conditions will be considered at length before showing how they are incorporated into a sliding scale system. They are: maximum demand, load factor, minimum charge, power factor, off-peak and limited service.

CONDITIONS AFFECTING POWER RATES

Maximum Demand.

The meaning of maximum demand will be most clearly understood if considered in the following manner. The instantaneous demand is the number of kw being drawn from the line at any definite instant. The interval demand is the average number of kw being drawn from the line during a specified interval of time, e. g., five minutes or fifteen minutes, and is equal to the arithmetic average of the instantaneous demands during the time interval. The maximum demand is the value of the greatest interval demand which occurs during the billing month.

The Duquesne Light Company's Schedule "F" bases their rate upon the maximum demand for any 15-minute interval, and they determine this quantity from a recording demand meter which records the interval demand for each 15-minute interval of the month.

Various modifications of the preceding method of determining maximum demand may be made. For example the West Penn Power Company determines the maximum demand (kw) for a five-minute interval and adds a certain portion of the maximum instantaneous demand occurring in the billing month, under certain conditions. For this purpose they obtain a complete monthly record of load with a curve-drawing watt-meter. From this record they determine the maximum five-minute interval demand, and if the maximum instantaneous demand is greater than 150 per cent of the maximum interval demand, then one-half of the excess above 150 per cent of the maximum interval demand is added to the maximum demand to obtain the (kw) billing maximum demand.

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*Note—While the analysis made in this article is based upon the two particular schedules named, the general principles apply to any power rate of the same general character. A reprint of the three articles, including both charts, may be obtained from Blast Furnace and Steel Plant, or from the author, Box 132, Pittsburgh, Pa., for $.......

It is, therefore, seen that the maximum demand is a measure of the capacity which a consumer "demands" and the producing company must provide equipment of sufficient size to serve this, and every other customer accordingly. It is obvious that while two customers might consume an equal number of kwh per month, one customer might have a maximum demand several times greater than the other, and since the producing company must provide more costly transformers and feeders for this customer's use (on account of the greater capacity necessary) and must have more reserve capacity at the generating station for him, it is only fair that the customer with the high demand should pay more for his power in order to cover his proportionate share of the fixed charges on the producing company's equipment. (It is well to point out in this connection that, if the two customers mentioned were generating their own power, the one with the high maximum demand would require a larger power plant than the other, and his power cost would be correspondingly higher.) It is obvious that the "postal plan" would not be equitable, as it would make the customer with a low demand pay a part of the fixed charges on the more costly equipment which was installed for another customer.

Load Factor.

Load factor is defined in the standardization rules of the A. I. E. E.† as "The ratio of the average power to the maximum power during a certain period of time. The average power is taken over a certain period of time, such as a day, a month, or a year, and the maximum is taken as the average over a short interval of the maximum load within that time." As applied to the present case, the basic "period" is a "billing month" and the "short interval" is 15 minutes for Duquesne schedule "F," and five minutes for West Penn schedule "J.'

The effect which load factor has upon power rates is similar to the effect of maximum demand, assuming two customers with similar loads and equal maximum demands, the fixed charges on the equipment which the producing company installs for each are equal. But if one customer operates his plant 600 hours per month (high load factor) and the other one operates only 300 hours per month (low load factor), the latter should pay a higher unit rate for his power than the former, because his share of the fixed charges is spread over a smaller block of energy (kwh). The energy charge portion of the unit cost would be equal for the two customers. (Again, if the two consumers were producing their own power, their fixed charges would be equal and the one with low load factor would spread his charges over a smaller block of energy, and his unit costs would be higher than those of the other plant with high load factor.)

The postal rate would not be equitable in this case, as it would charge both customers the same unit rate, and the customer with high load factor would be paying a part of the fixed charges on equipment used by the other customer.

Minimum Charge.

The discussion of load factor leads logically to the subject of minimum charge. The analogy of the isolated plant serves well again.

Suppose a manufacturing company operating their own power plant of 10,000 kw capacity, is forced by an industrial depression to suspend operations. The power plant will operate at almost zero load, furnishing energy only for lights, small machinery used for repairing, etc., and a reserve boiler unit under steam for fire pumps or other emergency. But the fixed charges on the investment of, say, $1,250,000, will continue, and they will be just as high as they would be if the plant were producing 5,000,000 kwh per month. The owners would not salvage their plant during their shutdown in order to save the fixed charges, as the plant must be had intact when business resumes.

Power producing companies in the Pittsburgh and other industrial districts are affected in just this manner by the present industrial depression. Many of their largest, as well as small consumers, have ceased operations, and since they use power in small packages or for emergency purposes only, they pray to be relieved from the "imposition" of the minimum charge, for which they are billed. But the producing company must continue to pay the fixed charges on the equipment installed, and must also hold their equipment in readiness to serve their customers the instant the customer closes his switch, so it is no more than fair to charge the consumer for the fixed charges on the equipment which is held for his use by the producer.

The West Penn minimum charge clauses were quoted in their contract in Article II. The Duquesne Light Company's clause was also quoted in Article I, but an interesting fact may be pointed out in this connection. The Duquesne schedule establishes the minimum charge as equal to the demand charge on 75 per cent of the connected load. Notice also that when the demand is not measured, it is taken as 75 per cent of the connected load. This means that the minimum charge is exactly the same as the demand charge, which is designed to defray the fixed charges, with a zero energy charge added.

Power Factor.

A real understanding of power factor requires a thorough knowledge of the characteristics of alternating currents, but it is hoped that the following explanation will serve the purpose of this discussion.

Low power factor has three objectionable effects, viz.: (1) reduction of capacity, (2) increased losses, and (3) voltage regulation.

1. In the case of an alternating current, the actual current flowing in the circuit may be considerably greater than that corresponding to the power being transmitted. The ratio of the power transmitting current to the actual current is called "power factor." The excess current, which always accompanies low power factor, is caused by induction motors, transformers, and other induction apparatus, and from the definition of power factor, it is seen that as the power factor

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†American Institute of Electrical Engineers.

decreases, the excess current increases. Now, since the capacity of any kind of electrical power equipment is limited by the maximum safe current for which it was designed, it is seen that where the excess current exists (i. e., where the power factor is low) all the equipment must be built oversize in order to carry rated load. This is shown in the following table:

Table 1.

Power Factor	Actual Available Capacity	Required Rated Capacity	Relative Transmission Loss
100%	10,000 kw	10,000 kva	100%
90	10,000	11,100	123
80	10,000	12,500	156
70	10,000	14,300	204
60	10,000	16,700	279
50	10,000	20,000	400

The last line of this table indicates that if a generator or other equipment is to carry 10,000 kw at 50 per cent power factor, it must be as large as though it were to have a capacity of 20,000 kw at 100 per cent power factor. Or, inversely, if a piece of equipment is designed for 10,000 kw at 100 per cent power factor, but is operated at 50 per cent power factor, its available capacity is reduced to only 5,000 kw.

2. The principle loss which occurs in all electrical machinery and circuits is the heat loss, and this loss varies as the square of the actual current flowing. This loss, then, varies inversely as the square of the power factor, and is indicated relatively in the last column of Table 1. For instance, the heat loss at 50 per cent power factor is four times as great as at 100 per cent power factor.

3. Satisfactory voltage regulation is much more difficult with low power factor, and as a result of this fact, other equipment, not only in the same plant, but also that in use by other customers on the same feeder, suffers from bad voltage regulation during large power surges under low power factor.

In view of the three reasons given, it is only fair to penalize consumers whose loads have low power factor, because a greater investment is made in equipment which the power company must install for their use, and they should pay the additional fixed charges thereon as well as for the increased transmission loss. The postal plan is not equitable in this case, since under such a rate all consumers would pay the same unit rate for power, regardless of their power factor.

Essentially, the power factor penalty correction is made by dividing the metered demand by the actual power factor, and multiplying by unity or by some other power factor which is established as "permissible.' Thus, the lower the power factor, the higher the billing demand, and the higher the cost per kwh.

Off-Peak and Limited Service.

Fig. 1 shows a representative daily load curve for a central station serving an industrial district. The average load for this day was 51,000 kw. and the maximum load was 71,000 kw; hence the load factor (daily) was 51,000 ÷ 71,000 = .72 or 72 per cent.

It will be noted that the peak load occurs from 7 A. M. until 5 P. M., except for the noon-hour slump. The central station must have sufficient capacity installed to supply the peak demand, with a certain amount of spare capacity for emergency, etc., and the fixed charges must be paid on the total equipment installed. Now if the producer could build up the load during the off-peak hours, the cost of producing that off-peak energy would be little more than the operating costs, as no additional equipment would be necessary. In other words, the daily load factor on the station would be increased. The producer can, therefore, afford to offer some inducements to his customers in the way of reduced rates for off-peak energy, in order to make more efficient use of his equipment.

As steel mills cannot advantageously avail themselves of off-peak service, the subject will not be discussed at length here, but where such service can be used, a considerable reduction in power cost can be effected.

Limited service, which is available only for small consumers under West Penn schedule "J," also offers reduced rates. Such customers are entitled to service during peak hours as well as during off-peak hours, but the producer may, at his option, suspend service to limited consumers in case of breakdown or other emergency when the normal operation of the producer's plant is hampered.

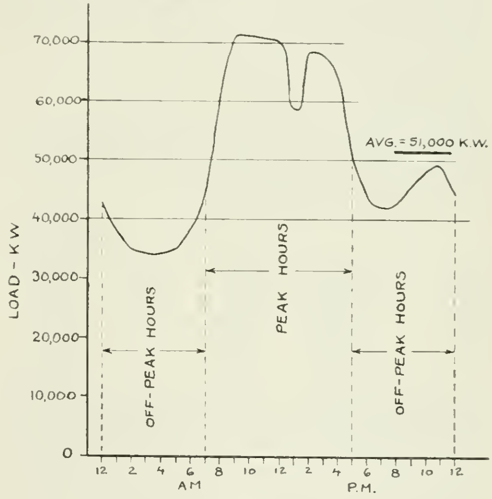

Fig. 1.

THE SLIDING SCALE RATE

From a consideration of the preceding factors, it is seen that the most equitable form of rate must take into consideration the amount of equipment installed by the power company for a given consumer's use, as well as the amount of energy which he consumes. The result is some form of sliding scale rate. Various forms of this type have been proposed and are in use, each attempting to provide a reasonable return on the investment, after defraying the manufacturing costs, and at the same time to distribute the total cost of operating the utility equitably among the various consumers. Sliding scales may be divided into three general types:

a. The block system, which consists of two or more blocks of energy with different rates applied to each block. The blocks may be established by a given number of kwh, or by a number of hours' use of the consumer's maximum demand. The West Penn wholesale rates are of this type, the first block being equal to

70 hours' use of the consumer's maximum demand and the second block being the remainder of the total energy consumption.

b. A demand charge, obtained by multiplying the consumer's demand by a fixed rate per kw of demand; plus an energy charge, obtained by multiplying the quantity of energy consumed by a fixed rate per kwh.

c. A combination of the above systems consisting of a demand charge and an energy charge, the latter made up by applying different rates to two or more blocks of the energy consumed. The Duquesne Light Company's rates are of the latter type.

Graphic Representation of Sliding Scale Rate Schedules.

Having enumerated and discussed the factors which establish the rates for a sliding scale, it will be instructive to see by means of reference to the charts, what effect these factors have in Duquesne schedule "F" and West Penn schedule "J."

Maximum Demand.

(Refer to chart for Duquesne schedule "F.")

By noting the intersections of the vertical line at 750,000 kwh with various demand lines, it is seen that the corresponding costs for this quantity of energy are:

Table 2.

Maximum Demand	Cost for Month	Cost per kwh	Load Factor	Penalty per Month (Above Cost at 100% L. F.)
1,027	$ 8,100	$.0108	100%	$ 0.0
1,284	8,600	.0115	80	500.
1,711	9,500	.0127	60	1,400.
2,570	11,100	.0148	40	3,000.
5,140	16,200	.0216	20	8,100.

From the table it is seen that the cost of 750,000 kwh may be anything above $8,100, depending upon the maximum demand; the cost at 5,140 kw demand being almost double the cost at 1,027 kw demand. The last column shows the "penalty" assuming the ideal condition to be 1,027 kw demand, which corresponds to 100 per cent load factor and which would require that this quantity of power be drawn continuously from the line throughout the month (730 hours).

All the quantities tabulated in Table 2 may be obtained directly from the chart, and if the chart is once thoroughly understood, the variations of these quantities can be vizualized more readily than from a tabulation.

Load Factor.

(Refer to chart for West Penn schedule "J.")

Table 2 also serves to show the increase in cost and penalty as load factor decreases. This may be better shown on the chart, however, by assuming two customers with equal maximum demands, say 2,400 kva and different load factors. If one customer consumes an amount of energy equal to 600 hours' use of his demand, the load factor will be 600 ÷ 730* = 82 per cent, and from the chart the cast is found to be $14,700, or $.0102 per kwh. If the second customer consumes an amount of energy equal to 300 hours' use of his demand, the load factor will be 41 per cent, and the cost is found to be $9,800 or $.0136 per kwh. Since $.0136 ÷ $.0102 = 1.33, it is evident that the latter consumer has been penalized 33 per cent for low load factor. As was explained previously, this higher rate is justified because the fixed charges on equipment installed for him are equal to those installed for the other customer, but are spread over a smaller block of energy, viz., 300 hours' use of the demand instead of 600 hours' use.

Minimum Charge.

The minimum charge for Duquesne schedule "F" is found by following the demand line, which represents 75 per cent of the connected load, back to the cost scale. For example, assume 2,400 kw connected load. 2,400 × .75 = 1,800 kw. The minimum charge is found to be about $2,300.

The minimum charge for West Penn schedule "J" is established as the equivalent of 25 hours' use of the maximum demand at any time established, subject to certain qualifications as quoted in Article 11. This cost cannot be determined from the chart for larger consumers, since this chart gives only the net costs, and term discounts are not applicable to minimum charges. The supplementary chart for small consumers, however, gives both gross and net costs, so the minimum charge can be determined as follows:

Suppose the maximum billing demand established for any billing month to be 2,000 kva. Twenty-five hours' use of this demand = 2,000 × 25 = 50,000 kwh. The gross cost of this quantity is determined by the intersection of the vertical line at 50,000 kwh with line "B." This is found to be $3,000 gross. Although term discount is not applicable, the two per cent prompt payment discount may be deducted; hence the minimum charge is $3,000 — $60 = $2,940 per month.

Power Factor.

(Refer to chart for Duquesne schedule "F.")

Since the power factor penalty charge is made by increasing the billing demand, the effect is similar to that shown in Table 1. Thus, the variation in the cost of 750,000 kwh at 3,000 kw metered demand is as follows:

(Note that the "permissible" power factor for 1,000 kw demand or over is 90 per cent.)

Power Factor	Billing Demand	Total Cost for Month	Penalty for Low Power Factor	Net Cost per kwh
100%	3,000	$11,950	$ 0.00	$.0159
90	3,000	11,950	0.00	.0159
80	3,375	12,700	750.00	.0169
70	3.860	13,650	1,700.00	.0182
60	4.500	14.900	2,950.00	.0199

Off-Peak and Limited Service.

(Refer to chart for West Penn schedule "J.")

The chart shows clearly the reduced cost of off-peak service. Under this clause, the billing demand is taken as 25 per cent of the metered demand. If the example shown on the chart were under this clause, the billing demand would be 3,000 kva × .25 = 750 kva, and the cost would be about $6,300, or $.0096 per kwh. This is only 60 per cent of the cost under general service.

Limited service effects a similar, but smaller saving, as the billing demand is taken as 70 per cent of the metered demand.

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*Since 1 month = 730 hours,

$$\text{Load factor} = \frac{\text{average power}}{\text{maximum power}} = \frac{\text{max. dem.} \times \frac{600}{730}}{\text{max. dem.}} = \frac{600}{730}$$

Procedure to Reduce Power Costs.

After becoming familiar with the effects of the load conditions upon the cost as just explained, the thrifty engineer will scrutinize the type of electrical and mechanical equipment which is to be incorporated into his plant, selecting the kind, type, and size that will not only be efficient in performing its intended functions, but such that will have load characteristics conducive to low power costs, and if possible, such that will tend to correct for poor conditions in other parts of the system.

As to the existing equipment under his charge, he will apply his portable recording ammeter and power factor meter to the supply point, and determine the characteristic of his demand and the time of day that excessive demands occur. He will then obtain similar data from each individual or group of power consuming devices; and having listed the offenders in rank order as to the penalties which they impose, he will determine whether the savings obtained by replacing the equipment or installing corrective devices would justify the necessary expenditure.

In order to have before him an ideal or "goal" at which to "shoot," the engineer should make the following division of his power cost, and then observe from month to month how near he approaches the "bull's-eye."

Refer to the example indicated on the chart for Duquesne schedule "F." The cost shown is $11,950. Now, if it were possible to reduce the penalties to zero, the billing demand would be 1,027 kw (load factor = 100 per cent) and the cost would be $8,100, which indicates a saving of $3,800 per month, or 32 per cent of the bill as rendered.

From the consumer's point of view, then, he is paying $8,100 for power consumed, and $3,800 for penalties.

Of course, it is impossible to reduce the penalties to zero, because ideal conditions cannot be obtained; but they can be approached by altering the conditions for which penalties are imposed.

Means of Reducing Penalties.

The conditions for which penalties are imposed have been thoroughly explained, and the methods of altering these conditions will be discussed in the same order.

It is assumed that the energy consumed per month has been reduced to a minimum, so the question of efficiency of the consuming devices is eliminated from this discussion. Efficiency is quite thoroughly understood by the engineers in charge of a plant, and great pains are taken to reduce the energy consumption to the least possible amount. Our problem, then, in reducing the monthly bill, is to obtain the lowest rate per kwh of energy consumed.

Load factor has been definited as the ratio: $\frac{\text{average power}}{\text{maximum power}}$, and it has been shown that the rate is reduced by increasing load factor, which means: by decreasing the denominator of this fraction, "maximum power," since the average power is fixed by the monthly consumption of energy. Load factor and maximum demand may, therefore, be considered together.

Maximum Demand and Load Factor.

Maximum demand occurs in periods of peak loads. The problem, then, is to shift some of the energy consumed during period of peak demands to other periods of lesser demands.

The problem of storage of large quantities of energy has never been satisfactorily solved. Means are available, however, for the storage of sufficient quantities to materially reduce peak loads on most kinds of equipment. These may be classified as: chemical storage, kinetic storage, and potential storage.

The most common example of the storage of chemical energy is the storage battery. The high first cost and large amount of space required, practically eliminate their use for industrial power loads. Further, they cannot be used with alternating current. Their use is restricted then to small consumers who rectify the alternating current to direct current.

The common example of the storage of kinetic energy is the flywheel. By an increase of rotating speed, the flywheel is made to "absorb" a quantity of energy which is made available again when the rotating speed is decreased. It is evident that since the use of flywheels is dependent upon a variation of speed, they cannot be used in direct connection with synchronous motors, as these machines must operate exactly in step with the generator from which they are receiving power. Flywheels may be used with direct current machinery or with alternating current induction motors, and wheels weighing more than 100,000 pounds are sometimes used for this service in connection with mine hoists or steel rolling mills.

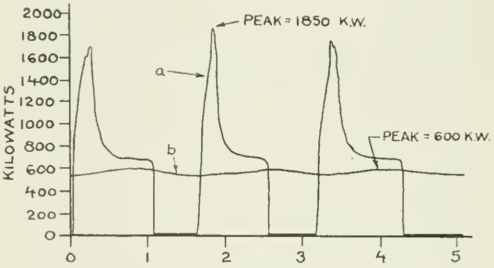

Fig. 2.

Fig. 2 shows graphically the reduction in maximum demand by the use of a flywheel set between the service line and a mine hoist motor. The kw line "a" shows the power delivered from the flywheel motor generator set to the hoist motor. If the hoist motor itself were receiving power directly from the central station under West Penn schedule "J," the maximum demand would be determined as follows:

The interval demand for the five-minute interval shown is 555 kw (obtained by means of a planimeter). This is assumed to be the maximum for the billing month. The maximum instantaneous demand is 1,850 kw. Since this is greater than 150 per cent of the maximum interval demand, one-half of the excess, or 509 kw is added to the maximum interval demand, and the billing demand is found to be 555 + 509 = 1,064 kw. Assuming that the hoist operates at the rate indicated by the curve, 200 hours per month, the monthly consumption would be 555 × 200 = 111,000 kwh. The cost of power for the month is found from the chart to be $3,150.

Actually, the flywheel set, irons out the peaks into a very smooth curve, as indicated by the line "b," which shows the power delivered from the central station to the flywheel motor generator. The maximum demand for this curve is 600 kw. Allowing 12 per cent for losses in the motor generator, the energy consumption would be 111,000 ÷ .88 = 126,000 kwh. The cost of this energy is $2,350, which indicates a saving of $800 per month, or 25 per cent, made possible by the use of the flywheel.

Potential energy may be stored by accumulating a fluid under pressure or at an elevated position. Where air is compressed or where water is being pumped, this means of storing energy may be used to advantage, and the peak loads on the driving motors thus reduced. Practically every air compressor is installed with a receiver on the discharge line, but too often the receiver selected is too small for the service, or additional compressors are later installed without providing additional receiver capacity.

Water under load head can be accumulated in overhead open tanks or reservoirs, and sufficient capacity is easily provided, but water under high pressure (e. g., 2,500 pounds per square inch, which is commonly used for presses and draw benches) must be stored in a closed vessel under pressure. The type of accumulator in common use is clumsy and costly, and for this reason many are in use which are entirely too small for the service.

The size and rate of operation of pumps* used with accumulators is important. The ideal combination would be a pump and accumulator of such size that the pump could operate continuously at an average rate just sufficient to meet the hourly demand for water, the accumulator taking care of all irregularities. Since this ideal condition can seldom be obtained in practice, a compromise is reached by selecting an accumulator smaller than the ideal size and operating the pump or pumps at a higher rate than the hourly average demand. It is obvious that the pumps must be cut out and in, occasionally, in order to prevent overcharging the accumulator, and that the greater the number of "off-time" minutes there are in each hour, the harder the pumps must work during the time they are on. To reduce the peaks, then, the pumps should be run at as low a rate as possible without allowing the accumulator to become empty. If the pumps are operated by direct-connected synchronous motors, the speed is not adjustable, and if cutting out one pump entirely is too much of a reduction, the only recourse left is greater accumulator capacity.

Power Factor.

Low power factor is caused principally by transformers and induction motors, and the lower the percentage of rating at which these are operated, the lower the power factor will be. They should be selected with wisdom, since it is usually considered necessary to provide excess capacity for future extension or an increased rate of operation, which requires larger equipment, while the power factor consideration favors smaller equipment.

High-speed induction motors do not reduce power factor to so great an extent as low-speed motors, and this is one advantage which reducing-gear drives have over direct-connected drives for low-speed machinery.

Synchronous motors and synchronous converters, when provided with normal field excitation, operate at unity power factor. If the field is under excited or cut off entirely, they operate similar to induction motors and the power factor will be reduced, little or much, according to the degree of under-excitation. If the field is over-excited, the power factor of the motor will be somewhat reduced, but the excess line current, instead of increasing the loss, will counteract some of the excess line current from induction-motors and transformers and decrease the loss, so that the power factor of the system as a whole will be increased.

On account of the necessity of direct current for field excitation of synchronous motors, they are not used in small sizes, but for motor-generators where flywheels are not used, and for large power drives generally, synchronous motors can often be used to advantage, and considerable power factor correction can be obtained.

In systems where power factor correction is needed, and which do not contain synchronous motors, auxiliary equipment can be added for this purpose, in the nature of static or synchronous condensers. Static condensers are much to be preferred, inasmuch as there are no moving parts; hence the operating losses are low and an attendant is not required. But commercial sizes are limited in capacity and only small sizes are available.

A synchronous condenser is nothing more nor less than a synchronous motor which is "floated" on the line and operated without load. By over-exciting the field to the proper extent, a current is generated in the line which counteracts the excess current in the system, so that unity power factor prevails at the service connection and back on the feeder until the load combines with another consumer's load with different power factor. If excess condenser capacity is provided, low power factor, due to other customers, will be partially corrected for. The West Penn schedule provides a special discount under "Line Regulation Discounts" (cf. Article II) to encourage the use of such apparatus.

Example of Reduced Penalties.

In order to show how the foregoing factors work out in practice, a hypothetical case is represented by Table 3.

The energy consumption and load factors are arbitrarily assumed, and the maximum demands are calculated therefrom. The billing demand is obtained from the sum of the individual maximum demands by applying an assumed diversity factor of 1.25. This means that the ratio of the sum of the individual maximum demands to the maximum demand of the whole system is 1.25, or that the maximum demand of the system is $\frac{1}{1.25} = .80$ or 80 per cent of the sum of the individual maximum demands. That the assumed initial conditions are not below the average is indicated by the fact that the load factor of the system, as based upon the billing demand, is 30 per cent, while the average load factor for twenty representative customers under this schedule which were examined by the author, was well under this figure. Also that the improved load factor, 45 per cent, is not impossible, is indicated by the fact that of the twenty cases examined, four have load factors above 45 per cent, and one is better than 64 per cent.

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*In this paragraph "pump" represents either pump or compressor, and "accumulator" represents either accumulator or air receiver.

Table 3.
Typical Comparison of Initial and Improved Conditions.
(Based upon West Penn Schedule "J")

	Initial Conditions			Improved Conditions			
	Kwh Consumed per Month	Monthly Load Factor	Kva Max. Demand	Kwh Consumed per Month	Monthly Load Factor	Kva Max. Demand	Reference Notes
Air compressors	120,000	.24	685	120,000	.48	342	(a)
Hydraulic pumps (high head)	80,000	.16	685	80,000	32	342	(b)
Hydraulic pumps (low head), centrifugal, for general service)	57,000	.40	195	57,000	45	183	(c)
Motor generator sets (general plant dc service)	400,000	.25	2,185	400,000	.34	1,610	(d)
Totals	657,000	...	3,750	657,000	...	2,477	
Billing demand, or composite maximum demand (diversity factor assumed 1.25)	......	...	3,000	......	...	1,980	
Composite monthly load factor (based upon billing demand)	......	.30	...	......	.45	...	
Net cost of power		(Initial) $10,490			(Improved) $8,590		
Net saving per month					$1,900		

Reference Notes.

a. Graphic ammeter showed that four compressors in operation were all "on" 33 per cent of the time and all idle 67 per cent of the time, swinging on and off at short intervals. By installing additional receiver capacity and re-arranging control device so as to cut off one unit at a time, it is found that two units would carry the entire load, one operating "on" 90 per cent of the time and the other one "on" 42 per cent of the time, dropping out of operation during periods of low demand for air.

b. Conditions similar to (a). Load factor doubled by installing larger accumulator and arranging control so as to cut off one unit at a time.

c. Induction motor drive. Graphic ammeter record shows that starting current is greater than normal operating current. By having the connections changed in starting compensator, the starting current may be reduced.

d. Graphic ammeter indicates that maximum demand occurs at 1:00 P. M. and corresponding hours when machine operators start a large number of motor-driven machines simultaneously and carelessly. Starting demand reduced by "staggering" (i. e., by starting the motors in groups at intervals of say one minute) and by re-arranging the resistance taps of large motors equipped with automatic starters, so that a lower starting current is drawn from the line.

The power factor penalty was not considered in the example as tabulated, since the motor generator sets, and likewise the pumps and compressors, might have been driven by synchronous motors at 100 per cent power factor. Assuming, however, that induction motors operating at an average of 70 per cent power factor were used, the billing demand for the initial conditions would have been

$$3{,}000 \times \frac{100}{70} = 4{,}290 \text{ kva}$$

and the bill would have been $12,900. Now, if a synchronous condenser be provided so as to obtain 100 per cent power factor, the new bill would be $8,590, as shown in the table. The total saving now becomes $12,900 — $8,590 = $4,310 per month. Further, if the synchronous condenser installed had sufficient capacity to obtain 90 per cent leading power factor or better at the customer's service connection, so as to earn line regulation discount, he would be billed for 657,000 × .95 = 624,150 kwh. The cost of this quantity of energy at 1,980 kva demand is $8,350, and the total saving then becomes $12,900 — $8,350 = $4,550 per month, or $54,600 per year.

The annual saving indicated would undoubtedly pay for the new receiver, accumulator, and condenser in about one year, and would pay a 100 per cent dividend on the investment thereafter. This is a better investment than any stocks or bonds on the market.

In conclusion, it is pointed out that the pursuit of economy should not stop with the highest obtainable thermal and mechanical efficiency. The exact analysis outlined in this article does not fit all cases, but the principles do apply to every consumer of purchased power under these and similar schedules; and to obtain the maximum saving, each system must be thoroughly analyzed by considering all the existing conditions.

MANY MEN NOT WORKING

Unemployment is still increasing in iron and steel works, according to the Bureau of Labor Statistics report for July, which shows a loss of 14,633 men from June, representing 12.7 per cent. The loss from July, 1920, is 89,000 men, or 46.9 per cent. Payrolls showed an even greater decrease, the drop from June to July being 24.4 per cent, while that for the year was 71.4 per cent. As a result, the individual pay envelope has fallen from $72.11 in July, 1920, to $38.17 last month—a cut of 47.1 per cent. This decrease in earnings is greater than the 43.5 per cent drop in the cost of living, from July, 1920, to July, 1921.

Comparative figures for June and July, 1921, and July, 1920, in iron and steel mills, automobile factories and car building and repairing shops follow:

Month	Number of Establishments	Number of Men	Half-Month Payroll	Average Pay Envelope
Iron and Steel—				
June, 1921	118	115,411	$5,088,831	$44.10
July, 1921	118	100,778	3,846,541	38.17
July, 1920	118	189,770	13,683,927	72.11
Automobiles—				
June, 1921	45	76,734	2,620,084*	34.15
July, 1921	45	79,064	2,622,596*	33.17
July, 1920	49	126,997	4,335,639*	34.14
Car Building and Repairing—				
June, 1921	59	39,335	2,670,021	67.88
July, 1921	59	38,378	2,272,954	59.23
July, 1920	62	65,386	4,082,301	62.43

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*Weekly.

Steel Foundry Makes Sugar Mill Machinery

Very Interesting Discussion on This Machining and Engineering Work—Roll Shells—Their Materials and Its Making.

By JAMES J. ZIMMERMAN,
Assistant Superintendent, Scott Foundry,
Reading Iron Company.

PART I.

It is not the writer's intention to present to our readers a series of articles dealing with the engineering and metallurgical facts, theories or principles underlying the successful and economical manufacture of sugar plant equipment, but rather his object is to confine his writing to the milling or rolling end of the industry, and to logically give data and information which may suggest to, or aid, the purchaser of such equipment to choose and choose wisely. At the same time he hopes to familiarize interested readers with this class of machine and engineering work.

Roll Shells—Their Material and Its Making.

Fundamentally, the basis of all successful milling plants is the rolls, hence roll shells, their material and making, are first discussed. There are three distinct materials for roll shells, viz.:

1. Cupola iron
2. Charcoal gun iron
3. Steel

Cupola iron roll shells are made from iron which in turn is made in a cupola, which is simply a shaft furnace. This consists of a vertical cylinder of steel plates lined with fire brick, with the top open to receive the alternate charges, in layers, of fuel and metal. At the bottom a blast is introduced, and the metal and slag withdrawn. In a cupola, the production of iron in tons per hour is dependent upon the inside diameter of the cupola, and the amount and velocity of the blast. A general idea of these ratios follow:

Inside Diameter of Lining in Inches	Tons Per Hour Melted	Cubic Feet Blast Per Second	Velocity of Blast Feet Per Second
36″ to 90″	4½ to 30	37½ to 250	5.33 to 5.66

Unfortunately the metal in a cupola can not be worked, and the grade of iron which is tapped out is dependent entirely on the calculated charge. This method of charging fuel and metal of certain analysis into the cupola, estimating the actions or reactions, and the losses, trusting to tap out a finished iron to a required analysis, or to change it by additions in the ladle, is very undependable. This practice is reliable enough for some castings, where limits are permitted, but not so for rolls requiring a definite composition determined by experience as necessary to produce certain results.

An air furnace of the type as is found in modern gray iron foundries is a hearth furnace whose fire box and melting chamber are separate. The draft, which is dependent on the chimney height, draws the flame from the coal fire over the bridge wall and on to the hearth, partially melting the charge and heating the walls and roof to incandescence, from which the heat is returned to the charge by radiation. It is this radiation from these surfaces which does the real work of heating and again superheating the metal.

Design of air furnaces varies according to the foundry as to the height of roof, area of fire box and hearth, location of tapping hole, charging doors, etc. They vary in capacity up to and beyond 20 tons. It can readily be seen that with this type of furnace a heat may be worked, and additions can be made within the furnace, in order to obtain a definite composition prior to tapping, as is required for rolls. The average heat in an air furnace, say of 12 tons' capacity, is about six hours.

Air Furnace Charcoal Gun Iron vs. Ordinary or Special Cupola Iron.

Advantages of air furnace charcoal gun iron over ordinary or special cupola iron from a purchaser's viewpoint:

1. A higher priced iron of better quality, as will be pointed out below, due to higher priced and more skillful labor and maintenance costs, than are required in cupola.

2. Greater physical strength, as follows:

	Tensile Strength	Elastic Limit	Modulus of Elasticity
Cupola iron	22,066	6,500	13,194,233
Air furnace charcoal gun iron	30,500	11,000	16,130,300

Above from (G. Lanza Trans. A. S. of M. E. x 187.)

Thomas D. West in his Metallurgy of Cast Iron, page 299, gives the following table, stating that the first analysis is from charcoal pig iron melted in an air furnace and that the second and third analyses are from a cupola and not charcoal iron.

No. of Analysis	Specialty Mixture	*Traverse Strength Per Square Inch	Tensile Strength Per Square Inch
A	Charcoal A. F. gun iron rolls, tc.	3,686	37,110
B	Heavy cupola castings	2,791	25.799
C	Light cupola castings.	2,115	20,655

Mr. West states that in analysis "A" the combined carbon being so high with low sulphur and silicon not far from 1.00 per cent, gives an iron far superior

No. of Analysis	Specialty Mixture	Sil.	Sul.	Phos.	Mang.	Graph. Carbon	Combined Carbon	Total Carbon
A	Charcoal A. F. gun iron rolls, etc.	1.19	.055	.408	.420	2.050	1.130	3.180
B	Heavy cupola castings......	1.05	.110	.543	.350	2.650	.330	2.980
C	Light cupola castings.......	1.83	.078	.504	.310	2.500	.430	2.930

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*From summary of 100 tests bar 1⅛ inch diameter x 12 inches between supports.

to any cupola iron. He attributes this gain in quality to the fuel and metal not coming into direct contact.

Mr. West states that in a cupola this combination may be closely approximated, but the working of the cupola, on account of the iron coming in contact with the fuel and blast, makes it a difficult and a very unreliable method to adopt.

3. Fuel and metal not in direct touch, hence absorption of sulphur from fuel less than in cupola. Sulphur in any proportion increases hardness, hence smoothness of the rolls and slipping during operation. It also increases shrinkages, hence internal strains and consequently breakage. It also unites with the combined carbon and produces hardness and brittleness to abnormal degree. This element is the most dangerous and detrimental in iron, and it is practically impossible to reduce it in any furnace. It is sometimes reduced by roasting the ore prior to its going through the blast furnace, where it is made into pigs for foundry use. In an air furnace the absorption is negligible, while in a cupola the iron, due to its contact with the coke, absorbs from 0.02 to 0.03 per cent from the coke. Logically the only way around the sulphur situation for roll practice is to begin with low sulphur or charcoal iron and work it under such process which does not increase this evil element, hence the air furnace.

4. Due to the same reason as in paragraph 3, oxidization is considerably lower, which consequently gives a better iron. Oxygen in iron raises the freezing temperature (or setting temperature) which shortens the life while pouring, hence little or no feeding can be obtained from risers or gates while cooling, hence voids and interior shrinkages. Such castings are unreliable and dangerous. Oxygen also has a tendency to increase combined carbon to a point where it destroys graphitic carbon, which gives the mottled texture, absolutely necessary for sugar mill rolls. Again it is a producer of gas, and, as Moldenke states, the reaction of the oxygen with the carbon forms carbon-monoxide gas. This actually goes on in the mold while the roll is being poured, as the cutting away of the skin of the casting, especially on the cope side. This is readily shown in the case of an oxidized iron and produces a beautiful collection of pin holes and gas pockets in the iron.

5. In air furnaces low silicon irons are used which are especially liable to oxidation, hence since silicon plays such an important part in the effect of the carbons which produce the combinations desired, it is easily seen that the air furnace again gains a point by the fuel not coming in contact with the metal. Silicon is a hardening element in cast iron, but on account of its influence on carbon it is usually considered a softener. During cooling it retards the combined carbon formation and increases the formation of graphitic carbon, which produces the mottled iron structure necessary in rolls. All of the above argues for control of the bath, as is possible in the air furnace, but not so in the cupola. Extremely low silicon produces a white fracture, while high silicon a gray, or beginning with hard white iron it passes on to a mottled iron, then to the soft gray iron, which is wonderful for machining but extremely low in strength.

6. The refining action of an air furnace, not obtainable in a cupola, with a flame almost reducing in character, prompts its use to the exclusion of other and cheaper means. The temperature of the furnace, about 2,400 to 2,600 degrees F., is not sufficient to melt steel, hence there is absolutely small chance for burning or oxidation of the metal. When the metal is melted it is protected from further action by a silicious slag until tapped and poured.

7. Since air furnace gun iron rolls are made from cold blast charcoal iron pig, they again claim superiority over ordinary or special cupola mixtures, for they not only obtain all of the advantages of the air furnace over the cupola as enumerated above, but also derive the following from the metal itself.

a. Because its tensile strength is greater, which runs according to grade used from 35,000 to 42,000 pounds per square inch.

b. Because the structure is finer and closer grained.

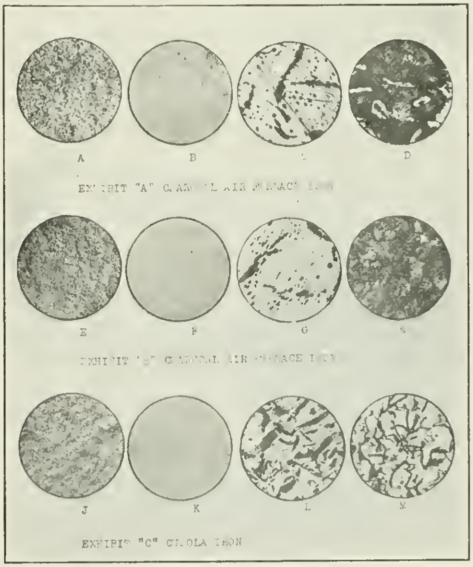

A
B
C
D
EXHIBIT "A" CHARCOAL AIR FURNACE IRON
E
F
G
H
EXHIBIT "B" CHARCOAL AIR FURNACE IRON
J
K
L
M
EXHIBIT "C" CUPOLA IRON

Fig. 1.

c. Because of the low sulphur and phosphorus.

d. Because the definite and straight cleavage planes of graphite, so pronounced in coke pig irons, are missing, the metal naturally is more firm, closer grained and stronger.

e. Let charcoal iron be melted in a cupola, and its contact with the coke will soon bring the superior qualities of it down to a level with coke or anthracite iron. Hence, to maintain its good properties the air furnace must be adhered to.

f. Production of cold blast charcoal iron is from 6 to 8 tons per day, and requires about 150 bushels of charcoal per ton of pig. Warm blast charcoal iron is from 15 to 25 tons per day. Coke and anthracite pig iron production runs into hundreds of tons per day.

8. At this point we quote Dr. Richard Moldenke, from his Principles of Iron Founding, page 435: "Many foundry men hold that they can do just as good work with a cupola as the air furnace, and, indeed, many castings are made today from furnace iron which could just as well come from the cupola. The fact

remains, however, that an air furnace roll is ahead of one made from the cupola for certain mill uses, and there is no getting round the situation."

9. Experience has shown that charcoal gun iron, which is hard enough to withstand strains and shocks, yet soft enough not to wear smooth, open grained enough to prevent slippage, yet close grained enough to prevent excessive corrosion caused by action of weather and juice, gives a longer life and consequently a cheaper roll for all sugar mill work. Reading Iron Company is prepared to guarantee their rolls of air furnace gun iron, with charcoal pig as a base, to give 30 per cent more service than those made from cupola iron.

In order to further bring out the difference between air furnace iron and cupola iron, and to show the superiority of the former, I am referring you to Exhibits "A," "B" and "C," showing respectively two grades of air furnace iron and one of cupola iron.

This is a highly refined product of the air furnace, known as gun iron, with high tensile strength of 31,000 pounds and other physical properties as set down in a former tabulation. It is low in phosphorus and sulphur, and has in it a small amount of manganese. The silicon, which is neither high nor low, is of the proper amount to sufficiently retard the combined carbon while cooling, and to change the proper proportion of same to graphitic carbon, in order to obtain the mottled structure or open grained iron necessary for sugar mill rolls. Primarily this iron was made from cold blast charcoal pig iron, and it is especially from this base that the iron obtains its excellent qualities.

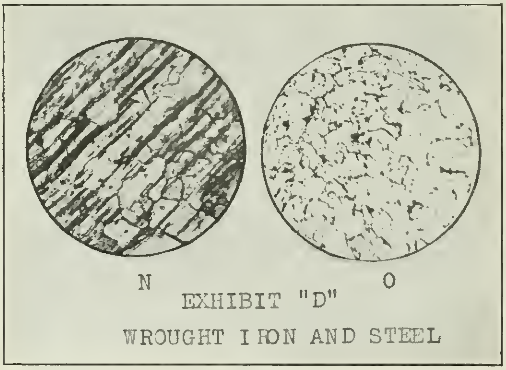


Fig. 2.

Photo "A" is an actual and full sized photograph of a fracture. The mottled or star-like structure produces the open grain so desirable. This is corroborated by Photo "B," which is of the same piece after machining.

Photo "C" shows an unetched micrograph of 100 diameters of the same piece of iron. Note the proper proportions of the carbons. The graphitic sufficiently prominent to insure above stated requirements, yet not in definite cleavage planes which tend to weaken the structure. At the same time the combined carbon is shown in great enough proportion to still maintain the high strength. This is corroborated by the etched micrographic photo "D" of the same diameter and of the same piece of iron.

These photos of this second exhibit show another specimen of high grade strong air furnace iron, also known as gun iron. Like the iron of Exhibit "A," it is also made with cold blast charcoal iron for its base. This iron is closer grained and consequently stronger than the former specimen.

Photo "E" shows the fracture and the close grain, making a strong and enduring iron of 37,000 pounds tensile strength, with other physical properties in proportion, wonderful for castings under heavy strains, such as housings, bed plates or rolls for steel or iron rolling, but unsuitable for sugar mill rolls. Photo "F" shows this piece of iron machined, and bears out the statements about photo "E."

Photo "G" is an unetched micrograph of 100 diameters taken off the same piece of iron. It shows at a glance that the structure is similar to that of the iron in Exhibit "A," but in addition shows a less amount of graphitic carbon, and more combined, hence greater strength and hardness. A study of the etched micrograph "H," of the same diameter and of the same piece of iron, further bears out this statement.

The specimen shown under this exhibit is of an exceptionally high grade cupola iron of 23,000 pounds tensile strength, not made from charcoal pig iron. It is somewhat higher in sulphur and phosphorus, and very much higher in silicon, than the specimens of Exhibits "A" and "B," and consequently the combined carbon is lower and the graphitic carbon higher, which in lieu of the effects of the differences in the proportions of the other elements, would naturally result in a less tough and weaker quality of iron. This will all be noted by a comparison of the unetched and etched micrographs "L" and "M," respectively, of 100 diameters each from this specimen with those of the irons of Exhibits "A" and "B." Particular attention is called to the increase of graphitic carbon, shown in micrograph "L," which forms in a greater number of plates than in the samples of air furnace iron, which results in the formation of straight and definite cleavage planes, which reduces the firmness and strength of the iron. This specimen of cupola iron shows no comparison of the actual and full sized photographs "J" and "K" of its fracture and machined surface, respectively, with similar photos of the air furnace iron, lead one to believe it an iron equal in strength, toughness and wearing qualities, had been produced. The micrographs soon contradict this assumption, and the analysis would strengthen the contradiction, while the physical tests would show a weaker and inferior iron.

Steel.

Steel, as it is spoken of today, embraces a multitude of mixtures, similar in structure yet vastly different in both chemical and physical qualities. Carbon is the element in steel which exerts the most influence upon its quality. Pig or cast iron contains up to about four per cent of this element; wrought iron only a trace; while steel lies between the two extremes, and its manufacture, therefore, refers principally to obtaining the proper proportion of carbon. One method of making steel is to burn out the carbon from the pig iron, as in either the Bessemer, open-hearth or electric furnace processes, and the other method is to take wrought iron and add carbon to it, as is done in the cefentation or crucible process. Details and differences between these processes may be studied in almost any reliable text book.

In writing of steel, as pertains to rolls, we write strictly of steel castings, and, further, to crusher rolls only. Steel castings, such as crusher rolls, are almost universally made from open-hearth steel by the acid process, although many foundries are now securing satisfactory results from basic furnaces. The superiority of the acid process over the basic is a point of much contention, and the writer feels that he can but adhere to custom in claiming preference for the acid process steel, principally for the following reasons:

1. Because in the melting process of an acid furnace, the melter has no control over phosphorus and sulphur, the most destructive elements in steel, while in the basic both elements can be appreciatively reduced. Hence a purer and better grade of material must be used, and the chances are that a better quality of finished steel will be obtained.

2. Because of the greater possibilities of higher oxidization in the basic furnace than in the acid. The principal effect of oxygen is a wild or unsettled steel, which naturally will, if poured, have an effect on the segregation or cooling of the casting. It gives to the steel a shorter life, hence voids, blow holes and abnormal shrinkages.

3. Because more is known of making steel castings by the acid process than the basic, due, of course, to longer experience, hence we feel that the acid process is beyond the experimental stage and that the results required can be readily and surely obtained.

The essential requisites of steel for castings follow:

1. That it must be low in sulphur and phosphorus, which cause red shortness, cold shortness, porousness, weakness, extreme brittleness or general unsoundness of quality.

2. That it must be dead melted and free from overoxidization or tendency to wildness.

3. That it must be hot and very fluid, in order that it may run well into the moulds.

Due primarily to the relatively large shrinkage of steel (3/16 inch per foot), large internal strains are set up and in order to relieve these stresses and to replace the original crystalline structure by a finer and more uniform one, steel castings are usually annealed, by bringing them up gradually and uniformly to a temperature of 800 to 900 degrees C., depending upon the composition of the steel, and allowing them to cool.

Since I have stated that steel castings, as pertains to sugar mill rolls, refer only to crusher rolls I want to add, however, that many crusher rolls are made from high-grade air furnace iron, such as heretofore described, and they perform very excellent service. A comparison, however, of the strength of steel with air furnace iron will at once show the average reader that for crusher duty steel is much preferable. Kerkaldy's tests published in the American Machinist, May, 1893, give for steel castings, from 44 tests, an average tensile strength of from 54,928 to 63,840 pounds per square inch. The main point is that the crusher rolls perform a more severe duty than the grinding rolls, and naturally should be stronger. Again this duty of crushing the cane, in addition to being more severe than grinding same, is more or less irregular and naturally subject to more shocks.

Although this company will make crusher rolls of air furnace iron, but positively not of cupola, and guarantee them, they feel that from experience they must recommend steel. It is, therefore, the policy of this company to furnish steel cast crusher rolls of from .40 to .60 carbon for all installations.

Shafts—Their Material and Its Making.

So far we have written only of the material for grinding and crusher roll shells, and insofar as these shells must have shafts in them, the writer feels that the material for these shafts should receive some discussion.

There are two classes of material from which shafts are made, namely:

1. Wrought iron
2. Forged steel

In the manufacture of wrought iron, the pig iron is remelted in a puddling furnace by charging about a half ton of metal, and while it is in a molten state it is stirred with a large hook by the operator, or puddler, and kept boiling so as to expose every part of the iron bath to the action of the flame, in order that the carbon may be burned out. The other impurities in the pig will, during the puddling, separate from the iron and form the cinder.

Now pig iron melts at about 2,100 degrees F. and wrought iron at about 2,800, and due to the temperature in the puddling furnace being low enough to melt the pig, but not high enough to maintain the wrought iron in a liquid state, the small particles of iron purify and partly congeal (come to nature). Thus they form a spongy mass in which small particles or globules of iron are in a semi-plastic state, which adhere to the fluid cinder which fills the cavities between them. This mass is taken from the furnace and either hammered or squeezed, in order to expel the cinder. While still hot this mass, as it comes from the squeezer, is rolled into flat bars called muck bars. This process of hammering, or squeezing, and rolling the bar back and forth, elongates the globules, and gives the iron a fibrous structure, and the more rolling or hammering which is applied to the iron, the closer grained it becomes, consequently giving it greater strength and ductility.

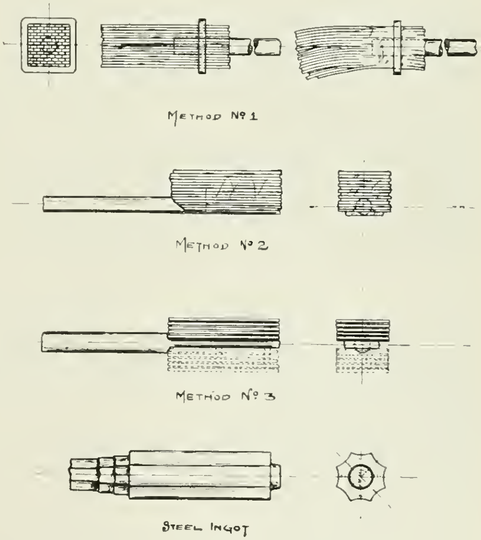


Fig. 3.

Fundamentally all steel is cast, if not into special castings, then into ingot moulds, and the ingots are either rolled or forged into required shapes or sizes. Steel, like iron, becomes closer grained and stronger with repeated hammering or rolling. Since I have already discussed steel casting, I shall not again go into the manufacture of it, and will simply compare the relative merits of wrought iron forged shafts with those of steel.

Wrought Iron Shafts vs. Steel.

While both steel and wrought iron are chemically very much alike, they are vastly different when compared physically. Owing to the globules of pure iron being coated with cinder which is partially expelled by working, as before explained, wrought iron has a fibrous structure, while steel which is produced, as before noted, in a liquid form where the cinder or slag all floats on the top and is removed before pouring, is a metal homegeneous in nature, or in other words, without fibre. This difference in structure may be seen by examination of Exhibit "D," Fig. 2, which shows micrographs of wrought iron and steel of 100 diameters, "N" shows the fibrous structure of wrought iron, and "O" the non-fibrous structure of steel.

When subject to vibrations or strain, torsional, bending, or otherwise, wrought iron will generally yield gradually and give warning, while steel will usually snap or break off suddenly. Wrought iron being composed of fibres, the fibres can break off one at a time without directly affecting its neighbor (like strands in a cable or rope), while any rupture in steel will extend very rapidly if not cause instant fracture.

It would be useless to argue that wrought iron has a greater strength than steel, for such would not be true, as the following figures will show, which have been set down by the United States Government as the physical requirements for heavy forgings or shafts. All tests to be made from test pieces taken from a two-inch bar.

	Wrought Iron	Steel
Minimum tensile strength.....	50,000	60,000 to 80,000
Minimum per cent elongation.	22	35 to 25

Reading Iron Company, whose wrought iron shafts are figured, according to their duty, with a high enough factor of safety to cover the lower strength, strongly recommends wrought iron, due to its structure, in preference to steel, claiming that the slight difference in costs more than warrants its selection. Reading also forges steel shafts and guarantees every shaft which leaves its plant.

In line with the above, let me state that the writer knows of a number of engine flywheel shafts which repeatedly failed when made from steel, causing much damage. These were replaced by wrought iron and are, and have been for a number of years, still in service. I am also advised that the older sea captains argue for wrought iron propeller tail and line shafts for their vessels „claiming them more reliable and better as before stated. I am further advised that vessels have been known to cross the Atlantic no less than six times with a cracked wrought iron tail shaft before replacement was made necessary by fracture. Such evidence should warrant the choosing of wrought iron for all sugar mill roll or gearing shafts.

Wrought iron, as I believe I have convinced you, is superior for shafts, yet wrought iron will fail. Most of the failures are due, however, to improper manufacture caused by an unscrupulous desire of the maker to increase profits at the expense of an inferior product. Remember the quality of forged wrought shafts depends entirely upon the method used in making up the pile or bloom, and the successful welding of the bars or sheets, from which it is built up into one solid mass. Note in the fagot method (1) that bars are piled together surrounding the porter bar and that they are held together at only one point by a square band. In this manner the pile is placed in a heating furnace, where it is heated for forging and where it is hoped that the pile will become sufficiently heated to permit welding. In this method the outside bars become heated and partially weld, but due to the distance to the center the inner bars in many instances are not welded when placed under the hammer. As a matter of fact, the Superintendent of the Reading Iron Company's forge states that in the majority of forgings made in this manner, failure is inevitable, and that the only excuse for employing such method is the desire to cut costs. On the right, illustration shows ho wthe pile looks when drawn from the furnace, and note the lower layers or bars have drooped and torn themselves from the pile even before reaching the hammer.

Method (2) consists of building a pile of sheets or slabs directly upon each other, and placing them in the furnace for heating and partial welding. Similar to method (1), the welding of the inside of the pile is dependent on the conduction of the heat through the successive plates from the outside. As previously stated for method (1), this second method of piling is unreliable and the chances of the pile being properly welded in the interior are slim.

Method (3) insures a perfectly welded pile, due to thin strips being placed in the middle and ends of the pile and between the slabs, of which it is made up, thus permitting the heat to pass through and bring all parts to a temperature sufficiently high to positively insure welding under the hammer. The pile is built up first as shown by full lines heated and welded under the hammer, then it is built up on the opposite side of the porter bar and welded as before and forged to the desired shape.

A sketch of a steel ingot is shown, and it is from ingots of this shape, which some times weigh many tons, that sugar mill roll and gearing shafts are forged, simply by heating prior to placing under the hammer or forging press. Please bear in mind that even though forging creates a closer grained and denser steel, it can not and does not eliminate piping or other defects which usually are found in the center. These defects, which are usually found to be the cause of failure, are seldom discovered before the shafts are placed in service. It is, therefore, suggested that all orders for shafts should specify hollow bored. This policy has been adopted by the majority of railroads, for it permits the discovery of defects in the center of the forgings prior to their acceptance and actual service.

(To be continued)

ERROR IN GORDON FOX'S ARTICLE

In the article "Electric Motor Drives for Traveling Cranes" published in the August issue of *The Blast Furnace and Steel Plant* magazine, errors occurred in the first two formulas on page 485. The first formula should be

$$\mathrm{DB} = (\mathrm{D_f} + \mathrm{D_a}) \frac{\mathrm{W}}{2000}$$

and the second formula should be

$$\mathrm{T_f} = \frac{\mathrm{D_f}}{\mathrm{D_f} + \mathrm{D_a}} \times 150$$

Effect of Overheating High Carbon Steel

Overheating Produces Many Undesirable Characteristics — The Greater Hardening Power of Oil and the Deeper Hardening Power of Water When Steel Is Overheated Are Explained.

By LANCELOT W. WILD, M.I.E.E.,
Automatic and Electric Furnaces, Ltd., London.

TO obtain complete surface hardening of a high carbon steel, the material must be heated until it becomes completely non-magnetic, and it must then be quenched.

If, instead, the heating is stopped at the end of the decalescence period, the steel will be only partially hardened. If, on the other hand, it is heated some way above the point at which the last trace of magnetism disappears, it will, although apparently fully hard by the file test, fail to stand up to its work.

Overheating produces the following undesirable characteristics:

A reduction of tensile strength.

A reduction of stiffness.

A reduced limit of elastic deformation.

A reduced impact test.

Reduced resistance to wear.

Reduced cutting power.

All this is well known, and is never now questioned by competent authorities.

Over-heating also produces another change, which has given rise to a good deal of controversy. Over-heating, followed by water quenching, increases the depth of hardening, and over-heating followed by oil quenching, increases the surface hardness. In other words, by over-heating, the same degree of hardness can be obtained with oil quenching as would be obtained with normal heating followed by water quenching.

SUMMARY

Heating steel to the completion of the magnetic change before quenching gives the strongest, toughest, best wearing and best cutting steel.

Over-heating gives increased hardness for oil quenching and greater depth of hardness for water quenching, but this is obtained at the expense of all those qualities most desired in hardened steel.

Over-heating steel increases the size of the grains, thereby increasing the thermal conductivity and reducing the cohesion; hence the deeper hardening power and reduced strength.

Large masses can be hardened as perfectly as small masses by heating to the point when the steel becomes entirely non-magnetic.

Steel that has once been overheated can only be fully restored to its best condition by being re-forged. A triple heat treatment can, however, be employed which will go a long way to improve its condition.

It is sometimes said that over-heating, followed by oil quenching, is preferable to normal heating followed by water quenching, as less strain is produced. This is a complete fallacy. If the surface of the steel is to be glass hard, martensite must be produced. Martensite has a lower density than troostite; hence, it is impossible to produce it without strain. It is not the means but the end that produces the strain. Overheating, on the other hand, weakens the steel and makes it less capable of withstanding the strain produced by the hardening operation.

The greater hardening power of oil and the deeper hardening power of water when the steel is over-heated is capable of explanation in three different ways.

Theory No. 1.

Le Chatelier has shown that when steel is quenched the temperature does not immediately start to fall at its maximum rate. It has been argued that when steel is normally heated, the rate of cooling has not yet attained its full value when the steel has cooled down to its critical temperature of transformation, so that the transformation is not always entirely suppressed.

If, however, the steel is overheated, the maximum rate of cooling is reached before the steel has cooled down to the transformation temperature, hence quicker cooling is obtained at the moment when it is most wanted. This is put forward in spite of the fact that Le Chatelier's curves show that the maximum rate of cooling is always reached with normal heating by the time the steel has fallen to the transformation point.

Theory No. 2.

When steel is heated to the magnetic change point, the cementite existing between the grains or crystals remains after quenching intact. When the steel is, however, sufficiently overheated this boundary cementite enters into solution and remains in solution after quenching.

The more cementite entering into solution the more it is likely to be retained on quenching, if the rate of cooling is not quite sufficient to retain the whole. Thus sufficient may be retained after overheating and quenching to produce great depth of hardening with water quenching, or complete surface hardening with oil quenching.

The writer favored this theory until experimental research proved it to be untenable.

Theory No. 3.

Overheating causes grain growth. Larger grains mean fewer boundaries for the heat flow to cross. From this one may infer that a higher heat conductivity would be obtained, and hence quicker rate of cooling. Thus, a piece of over-heated steel should cool more quickly than a normally heated piece of the same steel when quenched in the same liquid.

This theory appears to stand the test of experimental proof.

Experimental Proof.

For the experiments a sample of steel was chosen with a carbon content of a 1.2 pc and a manganese content of .2 pc. A bar of half an inch diameter normally treated was known to harden to a depth of about 1/16 of an inch only.

Three pieces of this steel were prepared and were treated as follows:

A. Annealed from magnetic change point. Reheated to just over magnetic change point and quenched in water.

B. Heated to 900 and quenched in water. Thoroughly annealed from magnetic change point. Reheated to just over magnetic change point and quenched in water.

C. Heated to 1,000 and cooled down in furnace. Re-heated to just beyond magnetic change point and quenched.

Under the microscope A and B showed martensitic structure on the surface and troostite in the center. C showed martensite throughout.

A showed a fine grain with good cementite network. B showed a still finer grain with cementite in the form of dust and short filaments. C showed a very coarse grain, with very complete cementite network.

On fracture A and B showed a very fine grain near the surface, and a larger grain in the interior, while C showed a very coarse and uniform grain throughout.

On impact test A proved to be the best, C being extremely brittle. On bending test the specimens came out in the same order, C being very deficient in stiffness.

C was the only specimen that hardened to the center. The heating for the final hardening was the same for all, so theory No. 1 is completely disproved.

C had its full complement of undissolved cementite and yet hardened to the center. Therefore, theory No. 2 goes by the board.

Theory No. 3 stands unconvicted, and, if nothing more could be said, would hold the field as the sole survivor. Its position can, however, be further substantiated.

Two pieces of steel were prepared, the one given treatment A and the other treatment C. A rather rough and ready comparison of thermal conductivity was made, and it was found that C had a conductivity from 30 to 40 per cent greater than A.

It appears from these experiments that deep water hardening and complete surface oil hardening can only be obtained at the expense of grain growth, which means weak steel and, generally, a very unsatisfactory product.

Incidentally emerges the fact that when steel has once been over-heated no reasonable heat treatment can completely restore to it its virtue, but if it must be used, the best thing to do with it is to quench at once, re-anneal as thoroughly as can be afforded, and then re-harden normally.

The Heat Treatment of Large Masses.

It is sometimes stated that large masses must be over-heated, as otherwise they cool so slowly that good hardening cannot be obtained. This is a fallacy, at any rate within the writer's experience, which extends up to masses of 40 pounds in weight.

If a laboratory test is made of a small specimen, and from the decalescence point thus obtained a routine is set to the hardening shop, two errors are likely to be made.

In the first place it is not possible to infer with precision the true transformation temperature from the thermal curve, as the transformation temperature is always higher than the decalescence point, and also depends upon the rate of heating.

In the second place the hardener is certain to underestimate the lag of temperature between the steel and the pyrometer. At the end of 45 minutes a 40-pound mass of steel has been found to be over 100 degrees below the temperature of the pyrometer placed in close proximity to the steel.

As the result of these two sources of error it is probable that the operators think they are over-heating the steel to attain their ends, when in reality they are only just heating it to the non-magnetic condition, and when they attempt to stop the heating at the temperature supposed necessary for a smaller mass they are really stopping the heating much sooner than they suppose.

Employing a 12-inch Wild-Barfield radiation furnace fitted with magnetic detector, masses of 40 pounds are now being hardened as a regular routine. Perfect hardening is being obtained, and there is no reason for supposing that larger masses than this cannot be successfully dealt with. In general the larger the mass the greater the difficulty of arriving at its temperature, and the more necessary becomes the employment of some device or other such as the magnetic detector, which tells one when the last grain of steel has completed its transformation.

AUTOMOBILE RACE FOR THE STEEL TREATERS CONVENTION

George Desautels, chairman of the entertainment committee for the convention and exhibition of the American Society for Steel Treating in Indianapolis, September 19 to 24, has issued an announcement of a match race between Frontenac and Duesenberg automobiles. This 50-mile race will be staged on the speedway, Wednesday, September 21, at 10:00 A. M. This is the first time in the history of the speedway that the authorities have ever consented to let anyone stage a race of any kind on this track other than the annual race meet on Decoration Day. There will be three or four Frontenac cars and three Duesenberg machines. The manufacturers of these machines are located in Indianapolis and are great rivals. Other races are possible.

While the race will probably be the largest event and probably of the greatest interest to the visitors, Chairman Desautels has, nevertheless, arranged for golf and tennis tournaments and ball games between the Eastern and Western delegates. Dances, smokers, vaudeville and a continual round of enjoyment are promised for the visitors. The steel treaters are looking forward to having the largest convention and most enjoyable occasion in their history. Prospects for technical papers are up to expectations. The hotels are already reporting heavy reservations for the week of September 19.

The Logic of Roll Design

The Proportion of Wabbler to the Size of the Neck for Various Type Mills Are Considered—All Rolls Used In Similar Mills Could Be Standardized If Reason Rather Than Prejudice Were Used.

By W. H. Melaney.

PART V.

ONE of the conditions which appear to the manufacturer of rolls as very senseless is the fact that in rolls of the same diameter to be used under exactly similar conditions, there is a great multiplicity of sizes in roll necks and wabblers.

In other words, if you should select six rolls of same diameter which were to be used on exactly similar work by six different concerns, you would rarely find any two of them made identically. Yet there is no reason why all of them should not be of exactly the same dimensions, with the exception of the length of the neck, as this dimension would depend more or less upon the design of the housing in which the rolls are to be used. The neck must be long enough to prevent any interference between the coupling box and any projection that might exist upon the side of the housing. The cross section and design of the housing determines the minimum length that this neck should be. However, all other dimensions, such as diameter of neck, size of fillet, length and cross section of wabbler could be very easily standardized for all rolls used on the same size trains or for similar service.

This would obviate the necessity of the roll maker from carrying such a mass of patterns for the various sizes. This seems particularly wasteful when one size would do very nicely.

It is true that various individuals have entirely different opinions as to the merit or demerits of the various shapes of wabblers for rolls. However, if a careful analysis of conditions were made of the five in common use, as illustrated in Fig. 1, it would be found that in very nearly every instance the difference in opinion is based on prejudice, rather than reason.

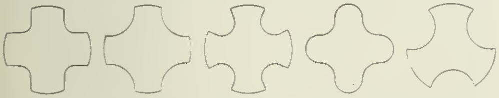


FIG. 1

The main essential of all these being that the coupling box, which is used to connect the driving spindle of the roll and which must continually change positions, due to the fact that the wabbler in most cases is just a rough casting and is rarely, if ever, exactly true with the neck. It must have a loose fitting coupling box in order to give a flexible connection. This box should have a firm bearing on the sides of the pods of the wabbler without lift, so that in driving the rolls under load there should be as little tendency as possible for the coupling box to grind or tear, and thus wear the wabbler out of shape. It must also have sufficient strength to transfer the power necessary to different rolling without breaking.

These conditions seem to be closely met by the straight cruciform wabbler as shown in cross section Fig. 2. This type of wabbler is used more generally on modern mills than any other type. It is especially suitable on rolls over which hard service is required. The following tables have been based on this design as being preferable.

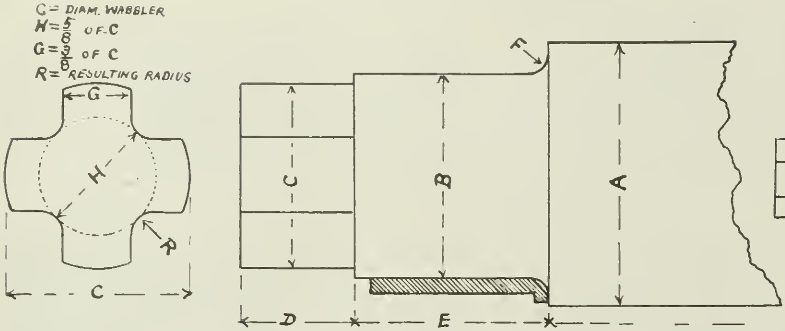
Using the formulae as outlined in the previous article for determining the diameter of the neck of the various types of rolls and which, as stated, was based upon rolls in general use, and then adopting the formulae of nine-tenths the diameter of the neck as the diameter of the wabbler in order that the wabbler may be smaller than the neck, as most wabblers are not machined and offer no interference with the neck, the writer submits a formulae for laying out the section of the wabbler as advocated and used by a prominent maker of rolls and roll machinery in the Pittsburgh district. This method seems to cover the essential parts of good proportions and construction, as outlined above.

This type of wabbler presents a straight bearing surface to the jog of the coupling box that drives it and is free to change its position by a simple sliding action without any tendency to tear the sliding surface or lift the roll.

The wear is fairly uniform and there is little tendency for the wabbler to wear taper. This is especially true if the coupling box is properly designed and has a groove recess cast in the middle of its bearing surface so that the end of the wabbler and the end of the connecting spindle when in position projects into this groove. This should be in the center of the coupling box and should prevent any pressure being brought to bear on the end of either the wabbler or spindle by the jogs on the coupling box. This in turn prevents any tendency of the jogs on the coupling box to wear taper, Fig. 3-K. This also prevents uneven end thrust on the wabbler.

Another expedient sometimes resorted to in preventing the wabbler from wearing taper was to cast a groove about one-half inch wide around the depressed portion of wabbler where it joins the neck, but this presented troubles in casting and has generally been discarded as being unnecessary. Fig. 3-L.)

The tables shown in Fig. 2, based on the formulae there shown, with the odd fractions eliminated for convenience, are submitted by the writer as a step in the direction of the standardization of necks and wabblers for rolls of the various types. The lengths of neck in these tables were selected from those in common use, but, as stated above, will depend to a great extent upon the design of the housings in which they are to be used. The diameter of the neck must not only be large enough to give proper bearing surface and strength enough to transmit the rolling strain, but should also be of proper proportion to the body of the roll, so that the time of setting or congealing of the molten metal in the neck after the casting of the roll



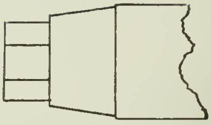


FIG J

GUIDE OR BAR MILL ROLL								
A	B	C	D	E	F	G	H	R
8"	1 11/16"	2 13/16"	4 1/2"	5"	1/4"	4"	6"	
9"	1 7/8"	3 1/8"	5"	5 1/2"	3/8"	4 1/4"	7"	
10"	2"	3 1/2"	5 5/8"	6 1/4"	1/2"	4 1/2"	8"	
12"	2 1/2"	4 1/4"	6 3/4"	7 1/2"	5/8"	5"	9"	
14"	3"	5"	8"	9"	5/8"	5 1/2"	10"	RESULTING RADIUS
16"	3 3/8"	5 5/8"	9"	10"	3/4"	6"	11"	
18"	4"	6 3/4"	10 3/4"	12"	3/4"	7"	12"	
20"	4 1/2"	7 1/2"	12"	13 1/2"	1"	7"	13"	
22"	5"	8 1/4"	13 1/4"	14 3/4"	1"	7"	14"	
24"	5 1/2"	9"	14 1/2"	16"	1 1/4"	8"	15"	
26"	6"	9 7/8"	15 3/4"	17 1/2"	1 1/4"	8"	16"	
28"	6 3/8"	10 1/2"	16 7/8"	18 3/4"	1 1/2"	8"	18"	
30"	6 3/4"	11 1/4"	18"	20"	1 1/2"	9"	20"	
32"	7 1/8"	11 7/8"	19"	21 1/2"	2"	9"	20"	
34"	7 3/4"	12 3/4"	20 1/2"	22 3/4"	2"	9"	22"	
36"	8"	13 1/2"	21 1/2"	24"	2"	10"	22"	
38"	8 5/8"	14 3/8"	23"	25 1/2"	2 1/2"	10"	22"	
40"	9"	15"	24"	26 3/4"	2 1/2"	12"	22"	

SHEET OR TIN MILL ROLL								
A	B	C	D	E	F	G	H	R
22"	17 1/2"	15"	7 1/2"	15"	1 1/4"	5 5/8"	9 3/8"	RESULTING RADIUS
24"	19"	17"	7 1/2"	15"	1 1/2"	6 3/8"	10 5/8"	
26"	21"	19"	8"	16"	1 3/4"	7"	12"	
27"	21 1/2"	19 1/2"	8"	16"	1 3/4"	7 1/4"	12 1/4"	
28"	22"	20"	8"	16"	2"	7 1/2"	12 1/2"	
29"	23"	21"	9"	18"	2 1/4"	7 3/4	13 1/8"	
30"	24"	22"	9"	18"	2 1/2"	8 1/4	13 3/4"	

DIAMETER OF NECKS AND WABBLERS AS COMPILED

MERCHANT MILLS 16" DIAM AND UNDER NECK = ROLL DIAM. × 0.625
" " OVER 16" DIAM — NECK = " " — × 0.67
PLATE MILLS — NECK = " " — × 0.75
SHEET AND TIN MILLS — NECK = " " — × 0.8
BLOOMING MILLS — NECK = " " — × 0.5625
WABBLERS ON ALL MILLS = — DIAM. OF NECK — × 0.9

ODD FRACTIONS ELIMINATED

FIG 2

will not take place so rapidly that it will set up undue casting strains between the neck and body of the roll, and thus render the roll more susceptible to breakage than if proper proportion had been observed.

This brings another feature into the problem of neck design, and that is the proper size of fillet to use at the point where the neck joins the body of the roll. The ideal condition of neck and body from a theoretical standpoint, and especially from the foundry man's point of view, would be to taper the neck from the full diameter of the roll to the final diameter of the neck as shown at J (Fig. 2). This would give the strongest possible neck and set up the least casting strains, but would introduce a number of other undesirable features which would cause more annoyance than the conditions they sought to overcome.

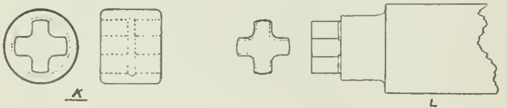


FIG 3

Therefore, the shape of neck as at present time used, that of a parallel bearing surface with the proper fillet at the juncture of neck and body has been selected as more suitably meeting all the conditions.

Rolls in use in rolling mills are not usually fitted with individual bearing brasses, as is true on other kinds of revolving machinery, but one set of rolls are removed from their bearings and another set of rolls are substituted on these same bearings whenever the occasion requires. These are expected to go into service and do their full quota of work without any change or preparation of these bearings for their new duties.

A straight parallel bearing has been found best suited for this condition, permitting the roll to shift endways within the limit allowed.

The fillet is simply a strengthening factor where the neck and body join and preferably should not be a part of the bearing surface. The fillet on the bearing brasses should have a considerably larger radius than the fillet on the neck of the roll so that the two surfaces do not meet, or more properly, the fillet on the brasses should be cut off at an angle of 45 degrees as shown in Fig. 2. This is desirable because any end thrust of the roll (and in most rolling problems this is a considerable factor) has a tendency to crowd the roll up on the fillet. If the fillet were a part of the bearing surface, the tendency would be to try to lift the roll off the parallel part of its bearing and thus give a very narrow bearing just on the fillet itself. The result would be a very hot streak around the fillet, sometimes hot enough to set the lubricating grease on fire. If this condition were permitted to go on, it would eventually mean a cracked fillet, due to too rapid expansion, and, finally, a broken-off neck.

This condition very often occurs on sheet and tin mills which are run hot, although the crowding up on the fillet in this case is due to a different cause, usually from the stretcher rods being pulled up too tight, not allowing for full lengthening of the roll when it becomes hot. On ordinary sheet mills this amounts to one-fourth inch or more.

If the housings are not spread apart enough to allow for this lengthening and the tie rods prevent any further spread, then the rolls crowd up on the fillet and a hot neck is the result.

On all rolls where end thrust is a feature, this thrust should be taken care of by the straight side of brasses above the fillet. Then there is no tendency to lift the roll.

This brings us back to the size the fillet should be, and it is obvious from the above that the fillet should be as large as is consistent, leaving sufficient straight side on the bearing brass to take care of the end thrust without excessive wear.

The fillets given in the table are based on this hypothesis.

Alternating Current in By-Product Plants

Two Papers Recently Presented Before Iron and Steel Electrical Engineers Compared — One Paper Covering the Use of Direct Current and the Other Alternating Current in By-Product Plants.

By W. V. DUNN,
Chief Electrician By-Product Coke Works,
Tennessee Coal, Iron & Railroad Co.,
Fairfield, Alabama.

IN presenting this paper, it is not the intention of the writer to boost either the one or the other systems of electrical current, but to first make clear the application of alternating current as applied in plants engaged in producing the by-products of coal, and then state such changes in the system that the writer would advocate were he called upon to build an entirely new plant.

The plant presenting the most concrete example to the knowledge of the writer is that of the Tennessee Coal, Iron & R. R. Company at Fairfield, Ala., it being exclusively an alternating current plant.

Plant Capacity and Products.

At Fairfield there are four batteries of 70 ovens each, built some 10 years ago, and two batteries of 77 ovens each, completed within the past year, making a total of 434 ovens, all of the Koppers type, with a consuming capacity of approximately 7,800 tons of coal daily and a production capacity of 5,200 tons of coke; 85 tons of ammonium sulphate; 75,000 gallons of tar; 93,000,000 cubic feet of gas. This on a 24-hour day.

All of this material is handled several times during the process of manufacture by machines electrically driven except the gas, which is exhausted from the batteries by means of turbine driven centrifugal exhausters and boosted to outgoing mains with turbine driven centrifugal boosters.

Power Supply.

Alternating current at 6,600 volts, 25-cycle, 3-phase, transmitted from another works over two circuits of No. 4/0 stranded copper, is stepped down to 240 volts. Six 300 kva transformers being used with three 300 kva transformers as spares.

Power Used in Plant Proper.

Alternating current, 240 volts, 25-cycle, 3-phase, is the system used in the plant proper except the lighting, which is 110 volts, 25-cycle, 3-phase, and an isolated pumping station which is furnished from still another source at 6,600 V. 60-cycle, 3-phase, and is stepped down to 2,300 volts. This is merely a water recovery proposition and will not be considered further in this paper.

Motor Equipment.

The motor equipment consists of 241 motors with a total rating of 6,284 hp, and in this list will be found the various types, synchronous, squirrel cage and the slip ring, of which many are mill type; the slip ring motors having both the open and semi-open rotor slots, which detail will be referred to in another part of this paper.

Method Used for Transmitting Power from Sub-Station to Distributing Points.

Power transmitted to the various parts of the plant distributing point is accomplished by using three conductor varnished cambric or paper insulated lead covered cables run in underground conduit, using both socket straight joint and drive straight joint, fiber duct. The duct ranges in size from 2 to 4 inches, the greater number being 4 inches. The size of the conductors 500,000 cm. Larger cables would be rather difficult to handle and especially so in long runs, where this size does not furnish sufficient carrying capacity, another cable is run and connected in parallel to the first. Duct lines having as many as 24 ducts carry a part of the cables, but this seems to be the maximum number as trouble may be experienced due to soft spots in the ground, causing the duct line to break. No duct line is allowed closer to the yard level than two feet, and preferably should be three feet. Manholes are constructed of concrete and large enough to allow working space around cables after they have been drawn in place. In all cases spare ducts are provided sufficient for future requirements. This, within reason, should be laid at the time of the original installation, as it will be found a very expensive proposition to make addition to an underground conduit system.

As in all other plants, there are continuous running or conveying equipment and machines that operate inter-

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Papers presented before Association of Iron and Steel Electrical Engineers, Birmingham Section, January 27, 1921. Complete papers with the discussions may be secured from the association headquarters, Pittsburgh, Pa.

mittently or as the cycle of operation of the plant requires. For convenience, the various operations may be divided into four groups as follows:

First—Coal handling equipment—continuous.
Second—Charging, pushing and quenching machine—intermittent.
Third—Coke conveying and screening machinery—continuous and intermittent.
Fourth—By-product equipment—continuous.

Coal Delivery and Equipment.

Coal is delivered to the plant in standard railroad cars of the drop bottom type, coming direct from the mines where it has been previously crushed and washed. Coal handling equipment consists of four incline belts that deliver the coal to bins directly over the batteries. Two of the conveying belts are driven by 75 hp squirrel cage motors and two by 50 hp motors of the same type. Two shaker feeds to each belt feed the coal onto the belt, each driven by a 7½ hp squirrel cage motor. This operation is continuous and very suitable for ac motor. Very often the belts operate for 24 hours without stopping. Flexible couplings should be interposed between motor and gearing. They are of extreme importance and mean a great deal to the life of the motor.

Charging, Pushing and Quencher Machines.

These machines and their duties are:

Larry cars which travel over the tops of the ovens on a track provided for this purpose, taking a weighed charge of coal from the bin before mentioned, and discharging it through doors in the top of the oven. When the oven is nearly full, the pusher leveling ram is run back and forth through a small side door, near the top of the oven, which uniformly levels off the charge. After the coking process has taken place, door machines remove the oven doors on each end of the oven. A guide attached to the door machine on quenching side is placed in front of the oven.

The quencher, or receiving car, handled by an electric locomotive, is placed to receive the coke. The pusher ram is then run through the oven, pushing the coke through the guide and into the car, from which it is dumped, after quenching, onto a receiving wharf.

There are one coal larry, one pusher and two door machines for each of the six batteries, while one locomotive serves two batteries for handling the coke.

Each larry is driven by a 30 hp slip ring motor.

Each pusher has one 30 hp slip ring motor, driving the leveler ram; one 75 hp slip ring motor driving the coke ram, and one 75 hp slip ring motor for bridge drive.

Each door machine is driven by one 12 hp slip ring motor. The door extractor of each machine is driven by one 12 hp slip ring motor.

The electric locomotives are equipped with two 50 hp slip ring motors. These machines are classed as doing intermittent service, their greatest distance of travel is limited to the length of two batteries, approximately 600 feet, and work back and forth very much like the charging car on an open hearth or reheating furnace floor crane. The power developed by these motors is by no means fixed, very often they are momentarily overloaded and often go to the pull-out point.

The method of getting current to these machines is quite a problem and doubly so for the reason that it is necessary to have three conductor rails with a safety shield under them and in some cases a guard angle on each side of the conductor. However, we think the problem has been successfully dealt with.

All of these machines are fed in two battery units through a set of conductor rails located above the oven doors in some cases, in other cases on columns supporting the battery platforms, and insulated with oak blocks which give very good service unless continuously wet.

If direct current motors were used a good saving would be effected on rails, insulators and supports. Also labor fabricating and installing, as only two rails would be required.

Coke Conveying and Screening.

Coke dumped on the wharf before mentioned is fed onto inclined belts which elevate it to a sufficient height to allow it to pass over a rotary grizzly screen, which removes the domestic coke and braize. The furnace coke being loaded into standard cars for shipment.

The equipment consists principally of belts, and screens, and are driven by squirrel cage motors and, in some cases, mill type motors are used. Very often belts are shut down fully loaded when changing cars at the loading end. In such cases, the motor starts up under full load. This complicates the classification between intermittent and continuous service.

In all such screening stations completely enclosed motors of either mill or mine type should be used. The dust and dirt from the coke has a most disastrous effect on the insulation of the winding.

By-Products Equipment.

The gas, the product from which the tar, sulphate of ammonia and benzol is taken, as before mentioned, is exhausted to the by-product building by centrifugal exhausters, electricity playing no part other than controlling the pressure in the mains by means of a governor, which consists essentially of a motor operated valve, the motor being controlled by a pontoon switch.

Pumps—Pumps ranging in size from 6 x 8 duplex to 16 x 16 triplex, the larger having a capacity of 1,500 gallons of tar per minute, aggregate a total of 400 hp motors driving pumps through silent chains are of sizes from 15 to 75 hp of the squirrel cage type, except the 16 x 16, which is driven by a 100 hp slip ring motor with flexible coupling. Their duty is to circulate tar through the gas mains for cooling the gas, also to transfer to different tanks such tar that has passed certain elimination processes. This is continuous duty 24 hours per day and all such drives should be equipped with ac motors.

Ammonium sulphate from dryers delivered on belt, conveyed to storage room where drag conveyors distribute it over storage space. These drives are usually small and require small continuous running motors from 5 to 10 hp, squirrel cage type. All precautions should be taken to prevent grounds, short circuits or anything causing a spark in these buildings.

Voltage of over 250 should not be allowed, and lighting preferably 110 volts.

Auxiliary drives around the benzol plant are steam driven due to the high inflammatory nature of the products. Lighting fixtures should be vapor-proof; metal conduits with sealed joints, and all conduit fittings should be thoroughly closed. Nothing over 110 volts should be allowed and switches should be mounted outside of building.

Cold Storage.

A reserve supply of coal necessary for Sunday and holiday operations is taken care of by a recently constructed stocking and reclaiming system, consisting of one Robins Bridge and several belt conveyors. The bridge span is 200 feet, travel of bridge 1,300 feet. This space constitutes the storage. Conveyors deliver the coal to trunk conveyor running the length of the storage and is then transferred to stocking conveyor or bridge from where it goes into storage. In reclaiming, the bridge grab bucket picks up the coal, dumps it into a hopper located on the bridge trolley and over the bridge reclaiming belt, from this belt onto main trunk conveyor to either of the incline belts.

Bridge and main conveyor driven by slip ring motor with magnetic control. Squirrel cage motor on all other conveyors in this unit, which consists of 12 motors, totaling 494 hp and consuming .33 kwh per ton stocking and .51 kwh per ton reclaiming.

An unusual feature is that the bridge has no line shaft connecting the end trucks, they being kept square by skew limit switches. No trouble has resulted from this feature. In case of trouble on any conveyor, except those on the bridge, the entire conveying system can be stopped from points 100 feet apart along the main conveyor. This prevents piling up of material.

Other Features.

Water for quenching the coke is furnished by one 3,000,000 gallon pump driven by a 100 hp squirrel cage motor, one standby unit as a spare.

Two Chicago pneumatic air compressors, 19 x 12 x 14 and 20 x 12 x 14 are driven by one 175 hp, 214 rpm and one 225 hp, 214 rpm. Synchronous motors furnish compressed air for the plant. These machines have mechanical unloaders for controlling the pressure.

Shops—Line shafts and machine tools are driven by squirrel cage motors except one 36-inch lathe which is driven by a 15 hp slip ring motor.

In Conclusion.

All such machines that are not stationary, having several motors to be supplied with current from a collecting system and where they are grouped as mentioned as charging, pushing and quenching machines, should be direct current. These machines are usually started, stopped and plugged under load. All of this causes high current peaks. Collecting systems are cheaper to construct, cost less to maintain, with resultant less trouble, where there are two contact rails instead of three.

The wound rotor motors will start the load and do very good service but will not stand up under the same service that a dc motor will. That seems to be the conclusion of those engineers who select dc motor for their most severe mill drives, such as screw down, front and back mill tables.

Wound rotors with semi-open slots mean each conductor has a soldered connection at each end and these are responsible for the greater number of break downs within the motor. The cost of a motor generator set is an item, but so are the switchboard panels, cables and switches, as well as other items which cost more for ac than dc. With an ac motor, the speed remains constant, whereas the acceleration above normal speed of the dc motor would prove of some advantage in many cases.

The cost of the equipment will not vary very much and if any, it would be in favor of the direct current.

A double system, using both alternating and direct current seems to be the best solution.

Direct Current in By-Product Plants

By E. P. WINTERS.

The by-product coke industry has made great strides in this country during the past ten years, and is yet perhaps in its infancy.

There are a number of types and designs of these ovens, but the general arrangement and cycle of operation of each type is very similar, and requires practically the same class of machinery for its operation.

The coking process consists in the distillation of coal in a closed oven from which the air has been excluded.

The usual oven is constructed of silica brick and has approximately the following dimensions: length 39 feet 6 inches, height 9 feet 10⅝ inches, and its walls are tapered from a width of 19½ inches on one end to 17 inches at the other.

During the coking process the ends of the ovens are sealed with doors held in position with suitable clamps.

The coal coming into the plant is delivered by means of a conveyor belt to a storage bin directly over the battery of ovens. Having reached this point it is dumped into a larry car which runs on a wide gauge track the width of which is about three-fourths the length of the oven. The larry then runs to a point directly over the oven to be filled and deposits its load through the charging holes in the top of the oven.

The usual amount of coal held by each oven is 12¼ tons, and it is of great importance that the coal be distributed evenly along the entire length of the oven. This requires some mechanical means of spreading or leveling as the coal is poured in through the charging holes. This is accomplished by a machine having the combined functions of leveler and coke pusher. The leveling arrangement consists of a long bar which travels horizontally through the oven near the top, and is repeatedly carried back and forth until the coal has been completely discharged from the larry and the oven is filled and leveled.

After the carbonization process is complete, the product is ready to be removed from the oven, quenched, screened and delivered into railroad cars for shipment.

Most of you are familiar with the general operation of a coke plant, but it is reviewed here in a general way just as an introduction to the discussion of properly deciding upon the equipment to be used.

In considering the electrification of by-product coke plants, let us first examine the load characteristics of the

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By E. P. Winters, Chief Electrician, Woodward Iron Company, Woodward, Ala.

various operations with a view of selecting drives which have characteristics most nearly conforming to the duty requirements.

Let us take first that class of machines which require the use of mill type and railway type motors. The most conspicious of these is the pusher and leveling machine. This machine usually has four motors, namely, the ram driving motor, the leveler motor, the machine travel motor and in most instances a door machine motor. Of these, the ram motor is the larger and has the heavier duty to perform. Here we have approximately 9¼ tons of coke to be pushed a distance of about 37 feet. The load is greatest just as the beginning of the operation, that is, the greatest amount of force must be applied at this time to start the mass of coke on its journey to the quenching car. The load becomes less as the ram head moves forward, due entirely to the fact that a lesser amount of coke remains to be handled; the amount of inertia stored into the moving parts being negligible.

Just here it might be well to mention one point which is likely to be overlooked, and that is the expanding properties of different coals in the process of coking. In the immediate district we are very fortunate in having a coal which shrinks perceptibly during carbonization, thereby clearing itself from the oven sidewalls. In some of the Northern plants this condition is not so favorable and the coke is held closely between the walls until the pusher ram has exerted enough force to break it loose.

In the pushing operation then we should have a motor capable of great starting torque.

There are two classes of motors which may be considered, first, the direct current series motor, and second, the three phase slip ring alternating current motor.

The characteristics of these two motors are too well understood to be reviewed at length in this discussion. However those features which have a direct bearing upon the case under consideration will be pointed out.

In the direct current series motor the maximum torque occurs in starting. The torque developed by this motor decreases with increasing speed and increases with decreasing speed. Under heavy load it slows down, thus relieving the power station of wide load fluctuations.

The polyphase induction motor is essentially a constant speed motor. It operates over a certain limited range of speed. It cannot exceed its synchronous speed, and when operating below its normal speed, it is less efficient. That is, when operating below normal rated speed, which can be done by introducing resistance into the rotor winding, this motor wastes that part of the power corresponding to the difference between the synchronous speed and the speed at which the motor is running. In other words, the induction motor, in order to produce a given torque uses the same amount of power at low speeds as it does at high speeds, although the power delivered to the machine which it is driving is reduced in proportion to the speed, and a corresponding loss in motor efficiency is effected.

The speed-torque characteristics of the induction motor is somewhat variable and dependent on sizes and types, but for a motor such as would be used for pusher service, the maximum torque would be developed when the motor is running around 70 per cent of its synchronous speed.

Moreover the alternating current motor does not produce nearly so active a machine as does the direct current motor, and this brings us to the consideration of the requirements of the leveler drive.

The leveler bar must be introduced into the chuck hole of the oven door, speed up quickly to about 90 feet per minute, stop, accelerate quickly in the reverse direction, and repeat this cycle for a number of times, depending upon certain local conditions. The induction motor cannot handle such a load so actively as can the direct current series motor, because the direct current series motor has a higher starting and accelerating torque and carries this high torque up to considerable speed.

Then comes the machine travel motor. The requirements of this drive are much the same as in the case of the electric locomotive. The machine is very heavy and bunglesome, and requires a high starting torque to get it under way. Here again the direct current series motor has the advantage.

The door machine motor, while only 5 to 7½ hp in size, has a duty cycle which is intermittent and which would be best taken care of by a direct current series motor, but would naturally receive the same class of motor as provided for the pusher and leveler, as it is mounted upon the same machine.

Then we have what may be regarded as the next most important machine, and that is the locomotive pulling the quenching car which receives the coke as it comes from the oven.

This is usually in the neighborhood of a 20-ton locomotive and handles a car weighing about 60 or 70 tons.

It is not my intention to exploit the field of electric locomotive propulsion in this discussion, but I wish to point out the one outstanding fact which applies to this specific case, and that is this: if the three phase induction motor is adaptable to any class of electric locomotive service, it is not to the locomotive which starts and stops at very frequent intervals. The locomotive in our case must make four starts and stops for every oven pushed.

It might be said just here that one of the most common errors in specifying electrical machinery for byproduct coke plants is to buy an express locomotive to do a switching locomotive's work.

Many plants are using a locomotive, the normal speed of which is ten miles an hour and more, when four or five miles an hour is plenty, and very much more satisfactory. This locomotive must carry the usual air compressor equipment capable of pumping about 100 cubic feet of air per minute for use of air brakes both on locomotive and quenching car, and to operate dump gates of quencher car.

The larry car really is an electric locomotive and the foregoing discussion applies to this piece of apparatus.

The only remaining motor drives of any great importance immediately around the ovens are the gas and air reversing machines.

There is no particular reason why we should distinguish between the advantages of alternating and direct current motors on these drives. If we are using an alternating current system of drives for the pusher, larry and locomotive, then the reversing machines should also be driven by alternating current motors. If we are using direct current to drive the principal machines, then we may as well use direct current for the reversing machines, for these motors only operate through a period of time of about 30 seconds every 15 to 30 minutes; so the size of motor generator sets, for producing the supply of direct current for the system, will not have to be increased.

As to controls for these drives, several types are in use. For the larry car a simple drum controller is all that is necessary, as is also true of the machine travel motor on the pushing and leveling machine. The leveling motor should be automatically accelerated by magnet switches, the operator controlling the starting and stopping by a simple reversing master controller. The leveler motor should be equipped with a solenoid brake which brings the bar to a quick stop when the current is taken off the motor. There should also be limit stops to prevent overtravel at either end of leveler bar.

The ram motor is very often controlled by a simple drum controller, but here, automatic acceleration is much to be preferred. Some plants have even gone so far as to equip this control with automatic slow down devices to prevent the ram gaining speed before the ram head presses against the face of the coke; then again to give slow speed as the last few feet of travel is reached. This drive should also have a solenoid brake and limit stops to prevent overtravel. The door machine may be controlled by a small face plate controller with very satisfactory results.

The locomotive may have a simple drum controller or magnet switches actuated by a master controller. The drum controller however is very satisfactory for the two motor locomotive.

The gas and air reversing motors are usually automatically controlled and their intermittent operation is actuated by a contact making clock. Push buttons are also provided in case the clock mechanism fails.

The hp ratings of the various oven drives will vary somewhat with local conditions, but the following list gives an idea of about the average size of motors used for the several operations: ram drive, 50 to 60 hp; leveler drive, 25 to 30 hp; pusher travel motor, 25 to 30 hp; door machine motor, 5 to 7½ hp; gas reversing motors, 5 to 7½ hp; damper reversing motors, 10 to 15 hp; larry motor, 25 to 30 hp; locomotive motors, 60 to 75 hp.

Other points which we must direct our attention include the difficulty and inconvenience of the three sliding contacts or current collectors used on three phase alternating current installations. With a direct current grounded system, only one current collector is necessary for each machine.

The current collector for the pusher is usually a shoe sliding along an insulated and protected rail.

The collector used in connection with the locomotive may be a slide shoe arrangement with the rail underneath the edge of the coke side bench, or an overhead trolley consisting of steel angle bars suspended from brackets protruding from the buck stays.

The larry car may have current collectors similar to that used in connection with the locomotive.

With reference to the various stationary motors used in connection with the plant facilities, there is no doubt that these should be induction motor drives. This includes shop motors, pump motors, conveyor motors and any others which have a constant speed load.

The substation should include transformers for lowering the pressure of the incoming power, and a motor generator set. Then there should be either a spare motor generator set or a steam driven generator to be used in case of failure of the motor generator set, or for use at such times as the source of power coming into the plant might be interrupted. This steam set is almost a necessity at times, for a ram or leveler bar may be left in an oven until badly damaged. Then too, this set may provide light at times of power interruptions at night. This is more of a safety measure however, but is worthy of consideration.

The line feeders from the substation are usually carried on towers or structural work and then through conduits to the control switches near where the power is utilized.

I believe that practically all the by-product coke plants in this country are using 220 volt current around the ovens proper. This has become pretty well standardized, and rightly so. The distances the low pressure currents are to be carried are not long; and insulation is easier for this voltage, especially in control apparatus.

The alternating current supplied to stationary motors may be either 220 or 440 volts. 440 apparatus is very satisfactory and admits of smaller line conductors for delivering current to these motors.

In conclusion, I would like to say it is my belief that the foregoing ideas are basically correct for the electrical apparatus which is available at this time; and that while some plants may have certain local conditions which would lead to some concessions, the majority of recent installations have been made along the lines pointed out in this discussion.

BY-PRODUCT PLANTS MAKE NEW RECORD

Coke and by-product resources of the United States, as indicated by production and statistical information just issued by the geological survey, today are in the most favorable position since these industries were established. Production today is at a particularly low point, due to the general business depression, but the potential capacities, as shown by the government figures are generally considered as tremendous.

The output of coke from both beehive and by-product ovens in 1920 totaled 51,888,000 tons, the old style ovens producing 20,980,000 tons, or 40 per cent of the total, and the retort ovens 30,908,000 tons, or 60 per cent. In this performance, the by-product ovens produced their record tonnage, surpassing the 25,997,580 tons of 1918, the previous high year, by 4,910,420 tons. Compared with 1919, the 1920 output of by-product coke was 5,764,458 tons, or 23 per cent, greater. Beehive production last year exceeded 1919's output by 1,330,000 tons, still, however, being nearly 10,000,000 tons under the 1918 figure.

How coke production and percentages, both as regards ovens, compare for the past eight years, 1914 excluded, may be seen in the following table:

	—By-Product—		—Beehive—		—Total—
Year	Net Tons	Pct.	Net Tons	Pct.	Net Tons
1913	12,714,700	27.5	33,584,830	72.5	46,299,530
1915	14,072,895	33.8	27,508,255	66.2	41,181,150
1916	19,069,361	35.0	35,464,224	65.0	54,533,585
1917	22,439,280	40.4	33,167,548	59.6	55,606,828
1918	25,997,580	46.0	30,480,792	54.0	56,478,372
1919	25,143,542	56.1	19,650,000	43.9	44,793,542
1920	30,908,000	60.0	20,980,000	40.0	51,888,000

The by-product coke output last year was from 11,038 ovens, according to the geological survey. This was 659 more ovens than produced the 25,143,542 tons in 1919. In the number of ovens, Pennsylvania heads the list with 3006, or 160 more than in 1919. Ohio is second with 1658 ovens, an increase of 50 in a year.

In production, Pennsylvania last year had an output of 7,710,000 tons of by-product coke, an increase of 1,837,000 tons, or 39 per cent.

Electric Furnaces for Making Steel

General Features and Advantages of Girod Furnaces—Report on Girod Furnace Located In Plant of Bethlehem Steel Company Published in Full — Electric Steel-Making Furnaces Classified.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.*
Birks Professor of Metallurgy at McGill University.

PART VI

THE Girod furnace was the earliest example of the electrode-hearth arc-furnace for use in commercial steelmaking, as it dates from the year 1905. It may be remembered, however, that Siemen's vertical arc furnace,* which is of this type, was used experimentally as early as 1882 for melting steel.

The typical Girod furnace is a tilting furnace, either circular or square in plan, having one central electrode entering through the roof and six water-cooled steel contacts passing through the hearth. While in operation the upper parts of these steel rods become melted, but the lower parts remain solid. When the steel has been poured, enough molten steel will usually remain to renew the contact rod as it solidifies. It will be difficult, however, to repair the hearth without danger of covering up the steel rods and so preventing the contact when the furnace is again started. The earlier Girod furnaces were square in plan, as is shown in Fig. 29, but more recent furnaces have been made circular. The latter design is better, as there is less wall area for a given volume, and, with a single electrode, the wall is heated evenly at every point, which is not the case with a square furnace.

The Girod furnace, in comparison with a series-arc furnace, is considered to have an advantage in the melting of cold scrap, because a large electric current at a low voltage will flow from the electrode evenly through the pile of scrap, thus heating and melting the scrap by resistance heating as well as by the arc. When the metal has melted, the electric current will flow in a somewhat horizontal direction through the molten metal from the central electrode to the four contacts which are located at the corners. This electrical flow will cause an electromagnetic circulation of the molten metal. Paul Girod mentions the "thorough electrification" of the steel as one advantage of his furnace, meaning that the electric current passes down through the steel, instead of merely skimming the surface as it might be supposed to do in a series-arc furnace. In view of the low electrical resistivity of steel, the passage of the current through the main mass of molten steel can have very little heating effect, but some heat may be produced at the entrance to the contact plugs where the cross-section of the conducting metal is more restricted.

The early furnaces had a capacity of $1\frac{1}{2}$ or 2 tons and were operated at a low voltage of 50 or 60. The low voltage followed naturally from the fact that there was but one arc in the circuit. This low voltage supply will tend towards greater steadiness of operation when melting cold scrap, but it increases the cost of the electric power, which is always supplied more cheaply at high voltages. The added cost of low-voltage power may be considered under two heads. In the first place, for a certain number of kilowatts supplied to the furnace terminals, the current will be larger

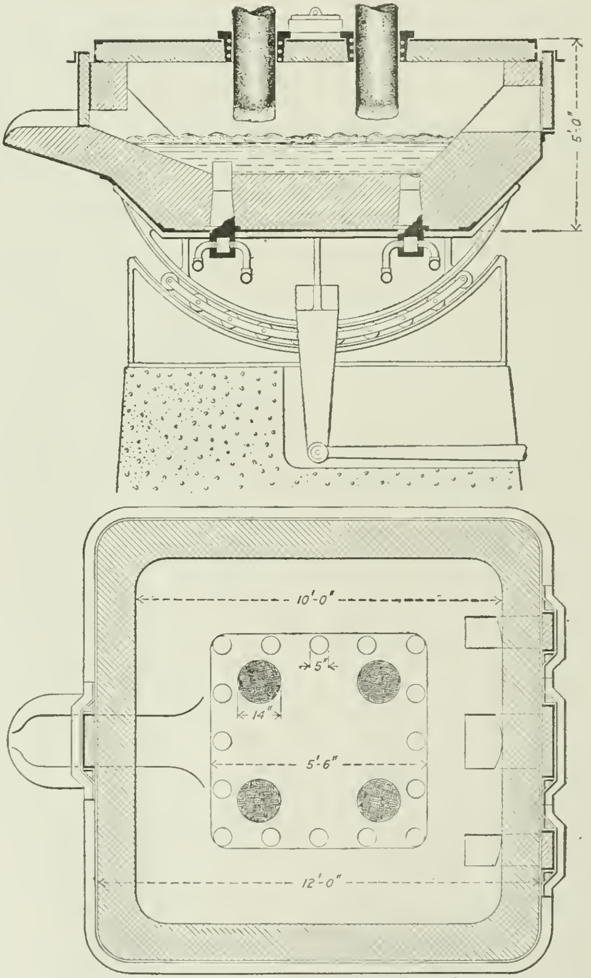

Fig. 29—Girod furnace with four electrodes.

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*Stansfield, "The Electric Furnace," page 4.

as the voltage is less, and consequently the cost and heating losses in the low-tension windings of the transformers and in the bus bars and cables leading to the furnace will be larger. Apart from this we must consider the losses in the electrodes themselves. A simple series-arc furnace has two carbon electrodes and a voltage of about 100, while a simple Girod furnace has one carbon electrode and a voltage of 50 or 60. Considering the carbon electrodes only, the Girod furnace, with half the voltage and half the electrodes would have, for equal power, an exactly equal electrode loss, providing that the electrodes were properly proportioned.† The Girod furnace, however, has the additional loss from the steel electrodes which form part of the furnace hearth. The losses in these, if properly proportioned, will be decidedly less than in the carbon electrode, and if the Girod furnace employs about two-thirds the voltage of the series furnace, the combined electrode losses will be about equal in the two kinds of furnace.

A more serious difficulty in regard to the operation of the Girod furnace arises from the fact that not only the single-electrode furnace, but also the multiple-electrode furnaces, Fig. 29, employ single-phase current. Electric power in large amounts is usually supplied from a three-wire three-phase system, and single-phase furnaces can only be run satisfactorily in groups of three, operating together so as to draw an equal amount of power from the three phases of the supply. Another method which was adopted by Girod in his early work was to use a large single-phase generator giving current at a suitable voltage and driven by a three-phase or two-phase motor. This arrangement is entirely satisfactory from an operating point of view, though the electrical losses are greater than with a simple transformer, but entails a large initial expense for motor and generator.

Three-Phase Furnaces.

The larger sizes of Girod furnace are now arranged for use with three-phase current. These furnaces are circular in plan and are provided with three movable electrodes. The steel contacts in the bottom, of which there are as many as ten, are all connected together and to the furnace shell. The arms carrying the electrodes are supported by steel masts attached to two sides of the furnace, while the service transformers are placed below the working platform of the furnace, and are thus quite out of the way.

The wiring diagram in Paul Girod's paper (5) shows that the primary windings of the service transformers are connected in delta, and the secondaries in star, with their neutral point connected to the furnace shell and steel bottom contacts. It might be supposed from this that the furnace resembled, in effect, a three-phase Heroult furnace, and that the bottom contacts would not carry any current if the phases were in perfect balance. A closer examination of the diagram shows, however, that one of the secondary windings has been reversed, which gives the phase relationships of this furnace. In consequence of this reversal there must always be a flow of current through the bottom contacts, because the currents entering the three electrodes do not balance each other. The amount of current flowing through the contacts will not, however, be equal to the current flowing through the upper electrodes, as in a single-phase furnace, but will be equal to the effective sum of these at any moment, that is twice the flow through any one of the electrodes.

The Girod furnace is made in sizes up to 15 tons. It is in use in a few American plants and in a number of European works. The following particulars of its operation were given a few years ago by Messrs. C. W. Leavitt & Co. of New York:

The power required is 175 kw per ton when melting cold charges in sizes up to 5 tons, and 150 kw in sizes of 6 tons and over. For refining molten steel, 125 kw per ton up to 5 tons capacity and 100 kw per ton in sizes of 6 tons and over. The current for small furnaces may be continuous or single-phase alternating, but for furnaces of 6 tons and over, three-phase current is used. The voltage is 65 in furnaces up to 4 tons capacity and 70 in furnaces of 6 tons and over. The frequency of the current may be as high as 50 cycles, but a lower frequency, such as 25 cycles, is preferable, and enables the power factor to be at least 80 per cent.

The length of each heat is about 7 hours when melting a cold charge and refining the steel, and from 1½ to 2½ hours when refining a molten charge. A furnace with one electrode can be used for 2½ tons of cold charge or 3 tons of molten charge. A furnace with two electrodes can be used for 5 tons of cold charge or 6 tons of molten charge. A furnace with three or four electrodes will treat 12 tons of cold charge or 15 tons of molten charge.

The electrodes are made large enough to limit the current density to 5 amperes per square centimeter, that is 25 amperes per square inch of cross section; referring, of course, to carbon electrodes. The electrode regulation is automatic even from the beginning of melting a cold charge. The furnaces tilt both forwards and backwards for pouring the steel or skimming the slag. The tilting machinery is either electric or hydraulic.

The cost of a furnace complete, with one roof and with electrode regulators and tilting machinery, but without electric generators or transformers is as follows (in pre-war prices):

1 ton furnace	frs. 13,000	=	$2,600
2½ ton furnace	frs. 18,000	=	3,600
4 to 6 ton furnace	frs. 25,000	=	5,000
8 to 12 ton furnace	frs. 35,000	=	7,000

The following particulars were given with regard to a furnace of 12 tons capacity in a European plant:

Maximum power needed, 1,200 kw. Power supply recommended, a 1,500-kva single-phase generator, 25 cycles, 75 volts, with regulation between 65 and 85 volts, allowing for an 85 per cent power factor. A transformer may be used instead of a generator, but it should have a larger capacity, so as to allow of a range of voltage and current.

Length of a heat, 7 to 8 hours with a cold charge, or 1½ to 2½ hours with a molten charge. Power employed varies between 900 and 1,200 kw. Energy consumed, 900 kwh per ton with a cold charge, or 150 to 250 kwh per ton with a molten charge.

Electrodes, four of 14 inches diameter weighing 600 pounds each. With cold charges these last about 10 heats, corresponding to a loss of 22 to 30 pounds, or 90 cents per ton of steel. With hot charges they last about 20 heats giving a consumption of 9 to 11 pounds, or 35 cents per ton of steel. These figures include the unused stub ends. At the present time threaded electrodes would no doubt be used so as to avoid this loss.

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†Stansfield, "The Electric Furnace," page 99.

With cold charges the roof lasts for 20 to 30 heats, and the furnace lining from 30 to 40 heats. With molten charges the roof lasts for 40 to 60 heats and the lining from 60 to 90 heats. The roof can be replaced in 15 minutes, but repairing the furnace lining takes about 36 hours.

The cost of the furnace repairs amounts to $1.60 or $1.70 per ton of steel using a cold charge, or to $1.20 or $1.50 per ton using a molten charge. Six men are needed to attend to this furnace assuming that the materials of the charge are brought to the furnace without their assistance.

At an American works making high-grade steel the power consumption was 900 to 1,000 kwh per ton and the other expenses, when melting and refining cold charges, were:

Labor	$0.80 per ton
Furnace upkeep	2.20 per ton
General expenses	.80 per ton
Electrodes	1.00 per ton
	$4.80 per ton

The following account (6) of a 10-ton furnace in the electric furnace department of the Bethlehem Steel Company was published in 1916; two more furnaces of the same size were to be added.

The furnace is circular in plan, 15 feet in diameter and 5 feet deep outside, of ¾-inch steel plate. It has one charging door opposite to the spout. The furnace rests on rollers and is tilted by means of a 15-hp reversing motor. It tilts towards the charging platform to discharge the slag, and in the other direction to pour the steel into a ladle. The furnace hearth, made of well-burnt magnesite or dolomite, is 20 inches thick, and the molten steel is about 16 inches deep.

Passing through the hearth, and connected electrically to the steel shell, are fourteen 3½-inch steel electrodes or pole pieces. Their lower ends are water cooled. The roof is an arch of 9-inch silica bricks and the hearth walls are built of magnesite bricks. Three 18-inch carbon electrodes are used, having a working length of about six feet. They are supported by water-cooled copper holders. The lower end of each electrode, while in operation, will be about 4 inches above the surface of the molten steel. The weight of this furnace is about 90 tons, including 35 tons of refractories.

The power is supplied from three 700 kva single-phase transformers. One terminal of each of these is connected to an electrode, and the other terminal to the furnace shell, which has heavy copper angles attached to it for distributing the current. Of the 700 kva supplied by each transformer, only 620 kva reaches the furnace, the rest being lost in heat in the conductors. The yield of finished steel is from 93 to 95 per cent of the cold materials charged, but the furnace is to be used largely for refining molten steel from 50-ton open-hearth furnaces or a 10-ton converter.

SILICON ADDITIONS TO STEEL

The effect of the time of adding silicon in the physical properties and the gas content of open-hearth steel is exhaustively discussed by E. Piwowarsky in Stahl und Eisen for June 10, 1920. An abstract of this important article has been published by Technical Review, London, as follows:

A number of opinions are held regarding the deterioration of steel by the small quantities of silicon present in the ordinary commercial steels, principal among these being the view that the silicic acid formed by the action of the ferrous oxide is retained by the steel in the form of a finely divided emulsified product, and that this weakens the cohesion of the steel, while the excess of silicon impairs the weldability of the material. The writer carried out a number of experiments and observations in steel works, with a view to clearing up this question, and determining whether and how it would be possible to enhance the good effects of silicon and to suppress the deleterious effects. A number of test heats were made, and the silicon added (in the form of ferrosilicon) at different stages of the pouring. It was found that when the ferrosilicon was added too early, the silicon losses were considerable and the quantity of silicon left in the final product was smaller than when the addition was made as late as possible.

A further series of heats was carried out to determine the effect of the gases, incorporated in the steel, on its qualities. For this purpose, the melts were made, as far as possible, using the same material and the same furnace. The ferromanganese required for deoxidizing the bath was added when the charge was completed, and time had been allowed for a state of equilibrium to set in between the bath and the slag. The ferrosilicon in half the heats was added by placing it in the bottom of the ladle at the usual time and in the other half it was added as late as possible by means of a special box arranged over the ladle and fitted with a flap-door at the bottom. The quantities of silicon were so selected as to give a final percentage of 0.20 to 0.22 per cent in the steel, as it was found that only with these percentages was the difference between the methods of adding the silicon to the bath sufficiently marked to be observed.

The charges were cast in round chill molds of 540 kg. in sets of 34 ingots, except in the case of the heats containing over 0.5 per cent carbon, which were cast in 750 kg. square ingots. The ingots were always cast from the bottom. Before the steel was cast, the ladle was left standing for 10 minutes or so, this measure being necessary especially in the case of cold charges, as otherwise the rolling discard of the steel is increased, due to the presence of the "emulsified" silicic-acid in the steel. Gas samples were then drawn off by a special arrangement. The results show that the gases given off by the liquid steel, where the silicon is added prematurely, contain a very large proportion of CO, which is the most harmful gas as regards the formation of blowholes.

Rolling tests were also carried out to show the amount of discard resulting (from the presence of occluded gases) when the silicon was added early and late. The following table shows the results:

Test No.	C.	Mn..	P.	S.	Si.	—Results of Rolling— Good Material, Kg.	Dis-card, Kg.	Dis-card, Pct.
(a) Ferrosilicon Added at Usual Time								
1	0.30	0.69	0.051	0.028	0.18	24,200	14,000	36.50
2	0.39	0.63	0.060	0.036	0.20	27,200	12,800	32.00
3	0.37	0.51	0.053	0.044	0.20	34,400	12,100	26.00
4	0.32	0.47	0.014	0.037	0.19	9,300	21,740	70.00
(b) Ferrosilicon Added Late								
5	0.36	0.54	0.027	0.038	0.22	30,250	6,800	18.00
6	0.35	0.57	0.043	0.032	0.24	32,700	3,700	10.00
1	0.31	0.52	0.057	0.038	0.25	28,600	4,900	14.60
8	0.40	0.54	0.027	0.040	0.26	36,200	4,100	10.00
9	0.37	0.58	0.064	0.040	0.25	34,900	3,800	9.80

Heat Treatment of Screw Stock

Prolonged Treatment at High Temperatures Is Necessary to Refine the Llamilar Structure Caused by Cold Rolling—Greatest Possibilities Lie In Case Carbonizing.

By A. A. BLUE, Metallurgist,
The Duff Manufacturing Co.

DUE to the ease with which it may be machined and to the fact of its generally being furnished in the cold rolled condition, the grade of steel known as "screw stock" is very popular with the machine shop man. Could it be heat treated to overcome its low physical properties, its field of usefulness would be largely increased.

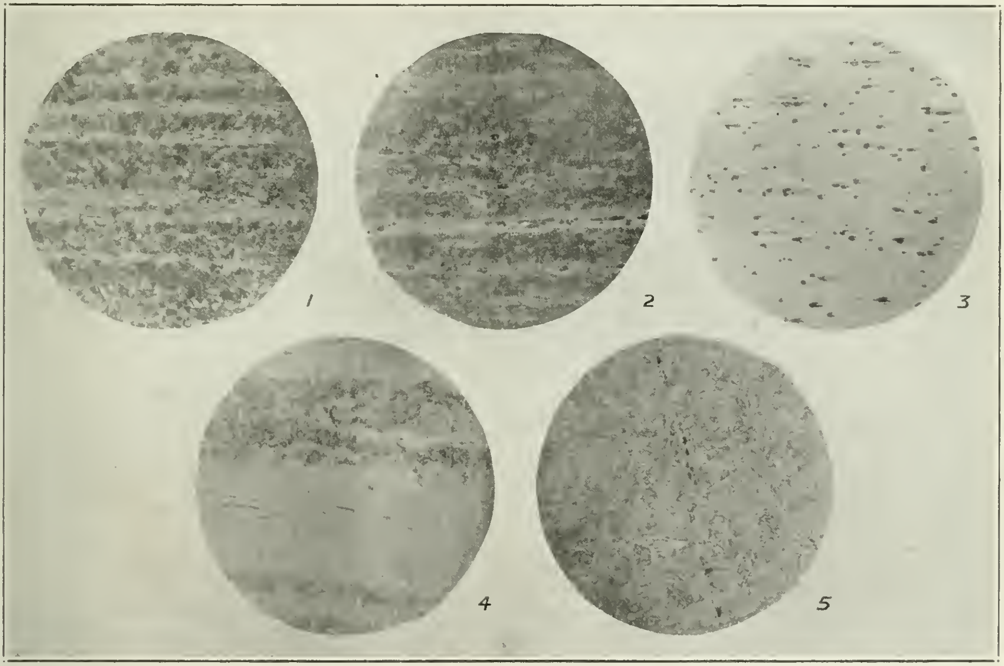

Fig. 1—Cold rolled screw stock etched in ten per cent nital. The segregation of ferrite with elongation of grain, due to first hot and then cold rolling, is at once noticeable.

Fig. 2—Same stock etched with Stead's reagent. The phosphorus segregation is clearly shown.

Fig. 3—Same sample as in Fig. 2 but unetched. The slag inclusions are clearly shown in this as well as in Figs. 1 and 2.

Fig. 4—Specimen heated to 1650 degrees F., held for three hours and slowly cooled. Equalization has just started.

Fig. 5—Specimen heated to 1750 degrees F., held for fifteen hours and quenched in running water. A practically uniform structure will be noted.

Difficulties To Be Overcome In Heat Treatment of Screw Stock.

However, it is under a number of great disadvantages from the points of view of mechanical strength and susceptibility to heat treatments of various kinds, as hardening and carbonizing. In the first place, to secure the machining qualities which make it so desirable to the production man, the composition is intentionally specified in such a manner that would be rejected in any other grade of steel for heat treatment purposes. Thus, the S. A. E. specification known as No. 1114, is as follows: Carbon 0.08-0.20; manganese 0.30-0.80; phosphorous 0.12 maximum; sulphur 0.06-0.12. Here are phosphorous and sulphur, which are ordinarily frowned upon in steel compositions, running about three times the amounts found in other grades, and the minimum for sulphur higher than the maximum in any other specifications. As is only too well known, these two elements of themselves in such large amounts greatly reduce the strength of the steel. Further, the phosphorous has a large tendency to segregate the carbon and manganese, thus causing weakened areas in an already weak material. Add to these disadvantages the tendency of the steel manufacturers to use heats of steel for cold rolled screw stock, which are unfit for anything else, because surface defects can be covered up in the cold rolling operation. This also leads to the use of cropped ends from ingots for the same reason. The result is seen to be an almost hopeless proposition for the heat treater. However, by proper methods, a certain degree of improvement may be obtained by heat treating screw stock.

Fig. 1 shows the ordinary appearance of screw stock with an alcoholic nitric acid etch, under the microscope. The segregation of ferrite is at once noticeable, with the elongation due to first hot and then cold rolling. The excessive prevalence of slag should also be observed. Fig. 2 etched with Stead's reagent, shows the phosphorous segregation. Again the large amount of slag is apparent. The extent to which slag is often found in such material is more readily appreciated by an examination of Fig. 3, showing a sample of screw stock, unetched. The analysis of the specimens just described is as follows: Carbon 0.19; manganese 0.62; phosphorous 0.088 and sulphur 0.087; a typical screw stock composition.

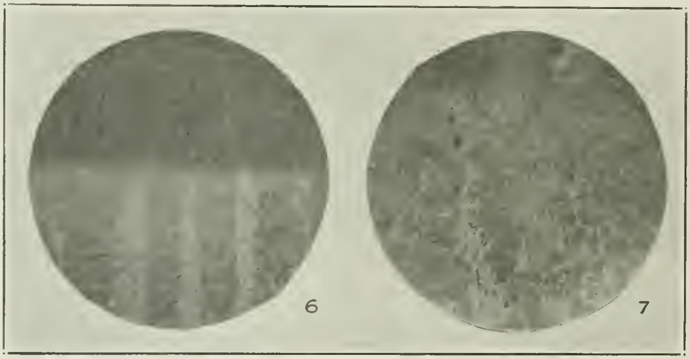

Fig. 6—Specimen of screw stock carbonized at 1650 degrees F., for two hours. Alternate bands of hard and soft steel are noted. Due to the segregation of phosphorus.

Fig. 7—Specimen carbonized at 1750 degrees F. for four hours. It will be noted that this structure is far superior to that shown in Fig. 6.

Possibilities in Heating Treating

Turning now to the heat treatment of such material, it is seen that the possibilities in this line lie in a thorough breaking up of the segregation of ferrite in its laminated form. This is found to require a rather drastic treament, involving high temperatures. Thus, Fig. 4 shows a piece heated to 1,650 degrees F., held for three hours, and cooled slowly, resulting in only the commencement of the necessary equalization. Fig. 5 is taken from a sample heated to 1,750 degrees F., held for 15 hours, and quenched in running water. This treatment has produced a comparatively satisfactory structure, although chains of slag are prominent.

The above treatments were carried out under laboratory conditions. In actual shop practice it has been found that holding at the quenching temperature of 1,750 degrees for one hour will produce results in keeping with the possibilities of this low grade steel. On parts approximately one inch in thickness, the following results may be obtained: Brinel hardness 170-207; scleroscope hardness 35-40. Tensile strength determinations were made on ¾-inch rd. bars of the following analysis: Carbon 0.16; manganese 0.56; phosphorous 0.098; sulphur 0.091. In the cold rolled condition this material showed:

Tensile strength	96,390 lb. / in²
Elastic limit	44,710 lb. / in²
Elongation	16.0%
Reduction in area	47.56%

The one redeeming feature of cold rolled screw stock from a point of view of mechanical strength is exhibited by the above figures. The cold rolling produces an excess of amorphous material between the grains of the steel, thus increasing its tensile properties. This is shown by the tensile and elastic limit figures given above which are high for such low carbon steel. Such results would not be obtained from hot rolled material of this low carbon content. It should be added, too, that the phosphorous aids in increasing these values. The effects of the phosphorous, sulphur, slag and segregation are apparent in the low values for elongation and reduction in area.

This treatment as given below, is seen to produce an increase of somewhat less than 10% in tensile strength in a bar of this size. On parts of larger dimensions, however, the increase would be more noticeable for the reason that the effects of the cold rolling on the untreated bar penetrate to a less extent. This would result in lower figures for tensile strength and elastic limit before treatment. Upon treatment, as the effects of the quenching would penetrate far into the material, the increased properties would be evident.

Another piece of the same bar was heated to 1,780 degrees F., held at heat four hours, and quenched in water. The following physical results were obtained:

Tensile strength	104,500 lb. / in²
Elastic limit	45,000 lb. / in²
Elongation	14.5%
Reduction in area	43.4%

Case Carbonizing Screw Stock.

Probably the largest field where heat treatment is attempted with screw stock is in carbonizing and case hardening. In this operation, as in ordinary hardening, the massive segregation of ferrite and pearlite is a great disadvantage. Fig. 6 shows a piece of screw stock cut transversely to the direction of rolling and carbonized on this surface at the ordinary carbonizing heat of 1,600 degrees F. for two hours. The result is at once apparent. Due to the unequal distribution of ferrite and pearlite on the surface, alternate bands of hard and soft steel are formed by the case hardening. This results in the hard and soft spots on the hardened surface, so often found in material of this kind. To avoid such a condition it is necessary either to first anneal the steel at 1,780-1,800 degrees or to carbonize at this temperature. The greater uniformity produced by the higher carbonizing temperature is shown in Fig. 7, carbonized at 1,750 degrees for four hours. High carbonizing temperatures should be avoided, however, as they produce a case sharply defined from the core, and not well graduated into the soft interior. Such cases chip off much more readily than those formed more evenly at lower temperatures. It should also be pointed out that effects of the high sulphur and phosphorous contents are much more pronounced when in combination with the high carbon produced in the case, and that all such case hardened articles will chip more easily than those made of low sulphur and phosphorous steels. For this reason, deep cases on screw stock should not be attempted.

In dealing with high quenching and refining temperatures, as 1750-1800 degrees, the scaling produced in ordinary treatment procedure as carried out in the usual shop furnaces is quite large. This is also accentuated by the impure condition of the steel under consideration. Therefore, especial precautions should be taken to minimize this effect as much as possible.

Conclusions.

In conclusion, it may be said that ordinary cold rolled screw stock of the general composition covered by the S. A. E. specification No. 1,114, presents nearly all of the undesirable features for a steel to be heat treated. However, by the use of drastic treatments, it is possible to produce appreciable improvements in it. Such material should only be used for parts requiring the least service.

New Discussion on the Physics of Steel

Application in Rolling of Effects of Carbon, Phosphorus and Manganese on Mechanical Properties of Steel.

By WM. R. WEBSTER.

THIS is a contribution for the proposed new discussion on the physics of steel. The former discussion on the subject started with the consideration of five papers presented at the Chicago meeting in 1893, and continued for several years. The Suggested Lines of Discussion, prepared by Doctor Howe, covered a wide field and added greatly to the success of the work. Naturally, the first step in a new discussion will be to remodel and bring up to date the old Suggested Lines of Discussion so as to embody all the important advances in the metallurgy of steel that have a bearing on the physics of steel and keep the papers and discussions within the field of work undertaken. This paper will be devoted to the practical application, in rolling steel, of the effects of carbon, phosphorus, and manganese on its tensile strength, with some suggestions on further research work.

Dr. J. E. Stead, in his paper Influence of Some Elements on the Mechanical Properties of Steel*, gave a complete review of all that had been done during the past thirty years. He gave full credit to all investigators who worked on these lines, also their results, with his views on same, and in many cases his own results. All of this data and much new valuable information were put in convenient shape for reference and study. To do this required a great deal of work, which is fully appreciated by the steel manufacturers and investigators.

The variations in the values given by the different investigators for the increase of the tensile strength of steel for each 0.01 per cent of carbon, phosphorus, and manganse were largely due to the steels they worked on, the large or small variations in the amount of the elements present, and the omission to take into consideration all the factors, from the blast furnace through to finished rolled material, that affect the character of the steel. For instance, a poorly made dirty steel requires considerably more carbon to give the same ultimate strength than a well-made clean steel with the same phosphorus and manganese content.

None of the values given for each element will apply equally well for all makes of steel or to different works making the same steel, yet each of us has contributed something to the fund of information that has enabled the present practical steel grading methods to be developed. Of course, the development of the quick chemical methods has greatly assisted in this work, especially the quick combustion for carbon determination, which has generally replaced the old color carbons, which at times were more or less guess work. Fortunately, several of our largest steel manufacturers have always relied on the work of different investigators and coöperated with them. These manufacturers deserve credit for this and the practical working tables that have been developed and put into daily use at their works. They can now grade their steel and roll it into the finished product with much greater certainty of its meeting all requirements of the standard specifications than formerly and with much less trouble than when they had to grade the steel from the results of the tension and bending tests of bars rolled from small test ingots from each heat of steel.

Should trouble occur under the present method of working, its cause is more easily located and corrected, as we now appreciate that uniform results can only be obtained by proper heating with proper reductions and medium finishing temperature in rolling. More good steel was formerly spoiled by too heavy reduction and by too high finishing temperatures in rolling than from any other cause.

Base for Structural Steel Calculations.

When bessemer steel was in general use for structural purposes, a base of 50,000 lb. per sq. in. (3515.4 kg. per sq. cm.) was taken, to which 1000 lb. (453.6 kg.) was added for each 0.01 per cent of carbon contained in the steel. This worked fairly well as a guide, the base

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Note—Paper to be presented before Wilkes-Barre meeting, September, 1921, of American Institute of Mining and Metallurgical Engineers.

*Jnl. Iron and Steel Inst. (1916), 44, 5.

being high enough to include the effect of the average manganese and phosphorus contained in the steel, but the results of tension tests of bars rolled from small test ingots necessarily were used for grading the steel. When acid open-hearth steel came into use, the base of 50,000 lb. (22,679.6 kg.) was found too high. In 1885 Mr. Salom wrote as follows:

> The influence of carbon on steel is better known than that of any other substance which enters into its composition. No one, however, so far as I am aware, has done anything more than formulate the general law that tensile strength increases with carbon, other things being equal. I have made the interesting observation that this increase is almost exactly 1,000 pounds for each 0.01 per cent of carbon. That is to say, assuming 0.01 per cent of carbon to be a unit of carbon, if to 45,000 pounds (20,411.7 kg) (the tensile strength of pure wrought iron) we add as many thousand pounds as there are units of carbon, we shall be able to make a close approximation to the tensile strength. Boiler-plate steel, for example, has about 0.15 per cent carbon, and 15,000 plus 45,000 equals 60,000 pounds, or about the tensile strength of boiler plate steel, etc.
>
> Of course this law only holds good where other things are equal. An undue amount of one or all of the foreign substances that enter into the composition of steel, or unusual physical conditions, would change the results entirely. It may be of value, however, as an indication that, when steel with a known amount of carbon does not possess a certain tensile strength, the other substances entering into its composition are present in undue proportion, or it must have been made under unusual physical conditions.
>
> The above law is not applicable to castings, where the presence of so much silicon affects, in a notable degree, the tensile strength derived from a given amount of carbon, and the physical properties are also affected by the fact that the metal has not been worked.

Mr. Salom did not give any value for the effect of phosphorus or manganese, and the tension tests of bars from small test ingots were used, as before, for grading the steel and applying it on the orders.

The conditions were practically the same in 1892, when the writer began his investigation at the Pottstown Iron Co.'s works except that the introduction of basic steel, with much lower phosphorus, had shown that the base of 45,000 lb. (20,411.7 kg.) was too high. No additional information on the effect of carbon was available and the information on the effect of manganese and phosphorus was conflicting; the writers generally claimed that there was no relation between the chemical composition and mechanical properties of steel that could be relied on. This added to the interest of the problem undertaken.

Effect of Finishing Temperature and Thickness of Rolled Steel on Tensile Strength.

At that time there was no general knowledge of the effect of finishing temperature and of the thickness of rolled steel on its tensile strength; if the steel manufacturers had such information, they kept it to themselves. To determine these questions, to be used as a starting point, a large number of slabs from the same heats of steel were rolled into plates of different thickness; the finishing temperatures of these plates were kept as nearly uniform as possible for each thickness of plates rolled. The tension tests showed that there was a decrease of 1000 lb. per sq. in. for each increase of ⅛ in. (3.17 mm) in thickness of plate from ⅜ in. (9.52 mm) upward, and an increase of 1000 lb. for each decrease of 1/16 in. (1.59 mm) down to ¼ in. (6.35 mm) thickness. This accounted for some 6000 lb. variation in the tensile strength of plates rolled from the same heat of steel, depending merely on the difference of the thickness into which the plates were rolled.

The importance of this is shown when we consider that there is only a range from about 45,000 to 85,000 lb. (3163.9 to 5976.2 kg. per sq. cm) tensile strength of steel used for structural purposes, and that 15 per cent of this 40,000 lb. difference is accounted for by the difference in the results from the same heat of steel when part is rolled into thick and part into thin material.

These results formed a good sound basis for all the work that followed and helped materially, as they covered the effects of about six to eight points of carbon. The writer at that time also found that the elongation and bending properties of rolled steel also depended greatly on the reductions in rolling, section rolled, finishing temperature in rolling, and rate of cooling. These points are well recognized today, and some of the mills take precautions in winter to keep the drafts of cold air from coming in contact with hot steel on their cooling beds; this is more important for the high than for the lower carbon steels.

The values referred to are in general use today with slight modifications to meet the special conditions at the different mills and the classes of material rolled. Some of the mills now follow a more direct method and, from their own records, increase the carbon as the thickness of their material increases on the same general plan as Doctor Stead refers to:

> In works where ship and boiler plates are produced, widely varying results are obtained with the same steel if it is rolled into plates of varying thickness, but this is due to mechanical work and variation in finishing temperature. The more work and the lower the finishing temperature, the higher will be the tenacity.
>
> In order to get the same static tests in ship plates of varying thickness, the carbon must he higher in the thicker plates. For instance, to meet Lloyd's specification and tests the relation between carbon and thickness of plate is as follows

	Per Cent		Inch
Carbon....	0.12 to 0.14	Thickness of plate....	3/16 to 5/16
Carbon....	0.15 to 0.17	Thickness of plate....	⅜ to ½
Carbon....	0.17 to 0.21	Thickness of plate....	½ to 1
Carbon....	0.21 to 0.24	Thickness of plate....	1 to 1½

> If all these plates were normalized at 900° C. and cooled at the same rate, the tensile properties would vary proportionally with the carbon.

This table shows that a wide range of carbon limits must be used to keep the ultimate strength of plates from ⅜ to 1½ in. (9.52 to 38.099 mm) in thickness within the required limits of the specifications. Particular attention is called to this, as some engineers still hold to the old idea, and claim that steel from the same heat should meet all of the requirements of their specifications, irrespective of the difference in thickness of plates or weight of shapes that it may be rolled into.

Webster† estimated the ultimate strength for pure iron, if it could be obtained, as 38,000 lb. per sq. in. (2671.7 kg. per sq. cm) and to this base added the effects of the other elements. This low base for pure iron was confirmed, in 1895, by Campbell,‡ when he used 37,480 lb. for basic steel and 38,600 lb. for acid steel, and more recently by Arnold, Brinell, Stead, and others, which is very gratifying to the writer.

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†Trans. (1892) 21, 766. Webster's first paper. The effects of carbon, manganese and phosphorus are taken from the same paper, the effect of sulphur not being considered, as most of the more recent investigations by others have shown that the effects of the ordinary content of sulphur are negligible.

‡H. H. Campbell: "Manufacture and Properties of Iron and Steel." New York, 1904. Eng. & Min. Jnl. Co.

Webster's value of 800 lb. per sq. in. (56.25 kg. per sq. cm) for each increase of 0.01 per cent carbon was confirmed by Campbell in his second investigation, in 1904, when he used 770 lb. for carbon by combustion and 820 lb. for carbon by color for basic open-hearth steel. Doctor Stead gives carbon an effect of 870 lb. per unit of 0.01 per cent. All of these values are considerably lower than the old value of 1000 lb. per unit for all makes of steel.

Webster's values for the effect of 0.01 per cent phosphorus starts with 800 lb. per sq. in. in the presence of 0.08 per cent carbon and increases to 1500 lb. (105.5 kg. per sq. cm) in the presence of 0.15 per cent carbon or over, that is, from the same effect as carbon to 1⅞ times the effect of carbon.

Campbell, in his first investigation, gave 950 lb. as the effect of 0.01 per cent phosphorus for basic steel and for acid steel 1050 lb. In his second investigation,[§] he gave 1000 lb. for each 0.01 per cent phosphorus for both acid and basic steels.

Doctor Stead states: "In reviewing the work of Stead and d'Amico, that the effect of 0.10 per cent phosphorus is comparable within certain limits with that of carbon."

In mill work, when grading good basic open-hearth steel, there is little need of considering the differences in the effects assigned to the unit of phosphorus, as the phosphorus in this steel does not generally vary more than four points, while the additions to the tensile strength, when estimated by the different methods referred to, varies from about 1500 to 3000 lb. per sq. in. Most of this is generally covered by the differences in the values given to the effects of manganese and carbon. Satisfactory results are obtained in rolling steel under all of these varying methods.

There has always been a great difference in the opinions of investigators and manufacturers of steel regarding the effect of manganese on its tensile strength. Some claim that the effect was slight, others that there was no effect on basic open-hearth steel until the manganese was above 0.40 or 0.60 per cent but most of them admit its effect on acid open-hearth steel. Webster's values for manganese varied, decreasing per unit as its content increased. He found the effect on basic open-hearth steel was less than on basic bessemer steel. In part they were as follows:

	Lb. per Sq. In.
Basic open-hearth steel with 0.35 manganese, 0.01 per cent	163
Basic open-hearth steel with 0.55 manganese, 0.01 per cent	151
Basic bessemer steel with 0.35 manganese, 0.01 per cent	223
Basic bessemer steel with 0.55 manganese, 0.01 per cent	189

Vosmaer in 1891, in Mechanical and Other Properties of Iron and Steel, gives the effect of:

0.01 per cent of carbon as 853 pounds per square inch.

0.01 per cent of phosphorus, one-fourth the effect of carbon, as 213 pounds per square inch.

0.01 per cent of manganese, one-fifth the effect of carbon, as 170 pounds per square inch.

Campbell in his first investigation gave, in basic open-hearth steel, 0.01 per cent manganese a value of 85 lb. He gives in his second investigation[¶] complete tables for the effect of manganese in both basic and acid open-hearth steel, showing that its effect per unit increases with the increase of the carbon in the steel.

Cunningham's rule, "To find the approximate tensile strength of structural steel to a base of 40,000 lb. add 1000 lb. for every 0.01 per cent carbon, and 1000 lb. for every 0.01 per cent phosphorus, neglecting all other elements in normal steels. Radical variations between calculated and actual strength indicate mixed steels, segregation, incorrect analyses, or unusual treatment in manufacture" was a good guide for basic open-hearth steel, as the base of 40,000 lb. (2812.3 kg. per sq. cm) was high enough to include the effect of the average amount of manganese in structural steel.

Grading of Steel.

During the last seven or eight years, some steel works, from their own data and tension tests of rolled material of different weights and thickness on former orders, have made their own tables for rolling similar materials on new orders. The results are most satisfactory, as the makers have at once the data required to grade and roll heats of steel best suited to comply with the requirements of each order. These tables cover not only the thickness of the steel but all other rolling conditions at the particular mill for which the table is designed. Formerly, it would have been almost impossible to collect such data, owing to the large number of specifications in general use. They were good, bad, and indifferent and covered all sorts of divisions of the steel. Through the work of the steel committee of the American Society for Testing Materials steel specifications were standardized and many of the old specifications scrapped. The other engineering societies coöperated in this work, and the whole range of structural steel is now covered by about six subdivisions, the limits of each covering a range of about 10,000 lb. (703.1 kg. per sq. cm) in tensile strength. Some of these overlap, as for instance, 55,000 to 65,000 lb. per sq. in. overlaps the 50,000 to 60,000 lb. and 60,000 to 70,000 lb. These standard specifications simplified matters very much in every way. The manufacturers have a larger tonnage to make on a given grade of steel than before, and it become easy for them to collect their records of tension tests and compile good reliable working tables. This enabled them to make better and more uniform steel. These tables are generally based on the results of tests made on steel containing not over 0.02 per cent phosphorus; for higher phosphorus, they add 1000 lb. (453.6 kg) for each increase of 0.01 per cent of phosphorus.

Steel works X uses practically the same form of table, based on records of rolling steel of not over 0.04 per cent phosphorus, but in applying heats with higher phosphorus it deducts 0.02 per cent carbon for each increase of 0.01 per cent phosphorus; that is, it is now using practically the values given by the writer in 1892, when he gave phosphorus 1⅞ times the effect of carbon when it occurred in steels of 0.15 per cent carbon and over. The grading of steel by these tables has for years given satisfactory results and confirms the work done at Pottstown.

About 1913, steel works A took several thousand tests of its ¾-in. round bars rolled from small test ingots of basic open-hearth steel, and grouped the results under each 0.01 per cent carbon, from 0.10 to 0.75 per cent inclusive, with the manganese from .34 to 0.96 per cent inclusive, advancing by 0.02 per cent Mn. The following note is taken from this table: "When phosphorus is greater than 0.02 per cent the figures should be increased at the rate of 1000 lb. for each 0.02 per cent that the phosphorus exceeds 0.01 per cent."

[§] Trans. (1905) 35, 772.

[¶] Trans. (1905) 35, 772.

[°] Trans. Amer. Soc. Civil Engrs. (1897) 38, 78.

The same course was followed with the ¾-in. round tests from its bessemer steel, the carbon limits are the same, but the manganese limits run from 0.34 to 1.10 per cent. As these tables are too large to embody here, the parts covering carbons 0.10 to 0.40 per cent and manganese 0.34 to 0.60 per cent are given. The increase in

Table 1—Steel Works A—Basic Open-Hearth Steel

Phosphorus under 0.031 per cent; manganese 0.34 to 0.60 per cent, varying by 0.02 per cent; carbon 0.10 to 0.40 per cent varying by 0.1 per cent. Average of actual tensile strength of ¾-inch round test bars rolled from test ingots.

When phosphorus is greater than 0.02 per cent the figures should be increased at the rate of 1,000 pounds for each 0.01 per cent that the phosphorus exceeds 0.02 per cent:

Per Cent Carbon	Per Cent Manganese 0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60
	Tensile Strength, Pounds per Square Inch													
0.10	50,145	50,595	50,950	51,300	51,700	52,100	52,440	52,720	53,000	53,400	53,800	54,200	54,600	55,000
0.11	51,410	51,790	52,090	52,390	52,720	53,050	53,340	53,595	53,850	54,245	54,640	55,025	55,390	55,760
0.12	52,675	52,980	53,235	53,480	53,740	54,000	54,245	54,470	54,700	55,090	55,485	55,850	56,185	56,520
0.13	53,945	54,175	54,375	54,570	54,760	54,950	55,145	55,350	55,550	55,940	56,325	56,670	56,975	57,280
0.14	55,210	55,370	55,520	55,660	55,780	55,900	56,050	56,225	56,400	56,785	57,170	57,495	57,770	58,040
0.15	56,475	56,565	56,660	56,750	56,800	56,850	56,950	57,100	57,250	57,630	58,010	58,320	58,560	58,800
0.16	57,040	57,140	57,240	57,340	57,435	57,530	57,675	57,860	58,050	58,445	58,840	59,180	59,455	59,730
0.17	57,605	57,710	57,820	57,930	58,070	58,215	58,400	58,625	58,850	59,260	59,675	60,035	60,350	60,660
0.18	58,170	58,285	58,405	58,520	58,710	58,895	59,120	59,385	59,650	60,080	60,505	60,895	61,240	61,590
0.19	58,735	58,885	58,985	59,110	59,345	59,580	59,845	60,150	60,450	60,895	61,340	61,750	62,135	62,520
0.20	59,300	59,430	59,565	59,700	59,980	60,260	60,570	60,910	61,250	61,710	62,170	62,610	63,030	63,450
0.21	59,775	60,025	60,275	60,510	60,785	61,055	61,365	61,700	62,040	62,470	62,905	63,320	63,720	64,120
0.22	60,245	60,615	60,985	61,320	61,590	61,855	62,155	62,495	62,830	63,235	63,640	64,030	64,410	64,790
0.23	60,720	61,210	61,700	62,130	62,390	62,650	62,950	63,285	63,620	63,995	64,370	64,740	65,100	65,460
0.24	61,190	61,800	62,410	62,940	63,195	63,450	63,740	64,080	64,410	64,760	65,105	65,450	65,790	66,130
0.25	61,665	62,395	63,120	63,750	64,000	64,245	64,535	64,870	65,200	65,520	65,840	66,160	66,480	66,800
0.26	62,285	63,020	63,755	64,410	64,700	64,990	65,310	65,660	66,010	66,335	66,660	66,990	67,325	67,660
0.27	62,905	63,650	64,390	65,070	65,405	65,735	66,085	66,455	66,820	67,150	67,480	67,820	68,170	68,520
0.28	63,530	64,275	65,020	65,730	66,105	66,480	66,860	67,245	67,630	67,970	68,305	68,655	69,020	69,380
0.29	64,150	64,905	65,655	66,390	66,810	67,225	67,635	68,040	68,440	68,785	69,125	69,485	69,865	70,240
0.30	64,770	65,530	66,290	67,050	67,510	67,970	68,410	68,830	69,250	69,600	69,945	70,315	70,710	71,100
0.31	65,800	66,585	67,370	68,155	68,560	68,960	69,370	69,785	70,200	70,570	70,940	71,305	71,670	72,030
0.32	66,835	67,645	68,455	69,260	69,610	69,955	70,330	70,740	71,150	71,545	71,935	72,295	72,630	72,960
0.33	67,865	68,700	69,535	70,370	70,655	70,945	71,295	71,670	72,100	72,515	72,930	73,290	73,590	73,890
0.34	68,900	69,760	70,620	71,475	71,705	71,940	72,255	72,655	73,050	73,490	73,925	74,280	74,550	74,820
0.35	69,930	70,815	71,700	72,580	72,755	72,930	73,215	73,610	74,000	74,460	74,920	75,270	75,510	75,750
0.36	70,665	71,530	72,400	73,265	73,545	73,825	74,170	74,590	75,000	75,455	75,910	76,295	76,610	76,920
0.37	71,400	72,250	73,100	73,950	74,335	74,720	75,130	75,565	76,000	76,450	76,905	77,320	77,710	78,090
0.38	72,130	72,965	73,800	74,630	75,120	75,610	76,085	76,545	77,000	77,450	77,895	78,350	78,805	79,260
0.39	72,865	73,685	74,500	75,315	75,910	76,505	77,045	77,520	78,000	78,445	78,890	79,375	79,900	80,430
0.40	73,600	74,400	75,200	76,000	76,700	77,400	78,000	78,500	79,000	79,440	79,880	80,400	81,000	81,600

Table 2—Steel Works A, Acid Bessemer Steel

Manganese 0.34 to 0.60 per cent, varying by 0.02 per cent: carbon 0.10 to 0.40 per cent, varying by 0.01 per cent. Average of actual tensile strength of ¾-inch round test bars rolled from test ingots.

Per Cent Carbon	Per Cent Manganese 0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60
	Tensile Strength, Pounds per Square Inch													
0.10	64,440	64,480	64,480	64,500	64,600	64,700	64,800	64,900	65,000	65,120	65,240	65,340	65,420	65,500
0.11	64,665	64,695	64,720	64,750	64,900	65,055	65,190	65,310	65,430	65,585	65,740	65,885	66,020	66,150
0.12	64,890	64,930	64,965	65,000	65,205	65,410	65,580	65,720	65,860	66,050	66,245	66,430	66,615	66,800
0.13	65,120	65,160	65,206	65,250	65,505	65,760	65,970	66,130	66,290	66,520	66,745	66,980	67,215	67,450
0.14	65,345	65,395	65,450	65,500	65,810	66,115	66,360	66,540	67,150	67,450	67,750	68,070	67,810	68,100
0.15	65,570	65,630	65,690	65,750	66,110	66,470	66,750	66,950	67,150	67,450	67,750	68,070	68,410	68,750
0.16	66,155	66,245	66,340	66,430	66,810	67,190	67,500	67,735	67,970	68,345	68,720	69,090	69,445	69,800
0.17	66,740	66,860	66,985	67,110	67,510	67,910	68,245	68,520	68,790	69,240	69,695	70,105	70,480	70,850
0.18	67,320	67,480	67,635	67,790	68,210	68,630	68,995	69,300	69,610	70,140	70,665	71,125	71,510	71,900
0.19	67,905	68,095	68,280	68,470	68,910	69,350	69,740	70,085	70,430	71,035	71,640	72,140	72,545	72,950
0.20	68,490	68,710	68,930	69,150	69,610	70,070	70,490	70,870	71,250	71,930	72,610	73,160	73,580	74,000
0.21	69,755	69,975	70,200	70,420	70,900	71,380	71,795	72,145	72,495	73,080	73,665	74,170	74,585	75,000
0.22	71,020	71,245	71,465	71,690	72,190	72,690	73,100	73,420	73,740	74,230	74,725	75,175	75,590	76,000
0.23	72,285	72,510	72,735	72,960	73,480	74,000	74,405	74,690	74,980	75,380	75,780	76,185	76,590	77,000
0.24	73,550	73,780	74,000	74,230	74,770	75,310	75,710	75,965	76,225	76,530	76,840	77,190	77,595	78,000
0.25	74,815	75,045	75,270	75,500	76,060	76,620	77,015	77,240	77,470	77,680	77,895	78,200	78,600	79,900
0.26	75,810	76,075	76,335	76,600	77,100	77,615	77,990	78,230	78,475	78,730	78,990	79,305	79,580	80,050
0.27	76,810	77,110	77,400	77,700	78,155	78,615	78,970	79,225	79,480	79,785	80,090	80,410	80,755	81,100
0.28	77,810	78,140	78,470	78,800	79,205	79,610	79,945	80,215	80,490	80,835	81,185	81,520	81,835	82,150
0.29	78,805	79,170	79,535	79,900	80,250	80,605	80,925	81,210	81,495	81,890	82,285	82,265	82,910	83,200
0.30	79,800	80,200	80,600	81,000	81,300	81,600	81,900	82,200	82,500	82,940	83,380	83,730	83,990	84,250
0.31	80,610	80,990	81,370	81,750	82,050	82,350	82,660	82,980	83,300	83,695	84,090	84,410	84,655	84,900
0.32	81,420	81,780	82,140	82,500	82,800	83,100	83,420	83,760	84,100	84,450	84,805	85,095	85,320	85,550
0.33	82,230	82,570	82,910	83,250	83,550	83,850	84,180	84,540	84,900	85,210	85,515	85,775	85,990	86,200
0.34	83,040	83,040	83,360	83,680	84,000	84,300	84,600	85,320	85,700	85,965	86,230	86,460	86,655	86,850
0.35	83,850	84,150	84,450	84,750	85,050	85,350	85,700	86,100	86,500	86,720	86,940	87,140	87,320	87,500
0.36	85,310	85,610	85,905	86,200	86,505	86,810	87,150	87,525	87,900	88,150	88,395	88,630	88,845	89,060
0.37	86,775	87,065	87,360	87,650	87,960	88,265	88,595	88,950	89,300	89,575	89,850	90,115	90,370	90,620
0.38	88,235	88,525	88,810	89,100	89,410	89,725	90,045	90,370	90,700	91,005	91,310	91,605	91,890	92,180
0.39	89,700	89,980	90,265	90,550	90,865	91,490	91,490	91,195	92,100	92,430	92,765	93,090	93,415	93,740
0.40	91,160	91,440	91,720	92,000	92,320	92,640	92,940	93,220	93,500	93,860	94,220	94,580	94,940	95,300

the tensile strength for the 30 points of carbon and 26 points of manganese is 31,455 lb. for basic open-hearth steel and 30,860 lb. for acid bessemer steel.

After several attempts to get a workable table of estimated tensile strengths that would agree with the averages of the actual tests of the basic open-hearth steel given in Table 1, the writer found that by starting with the base given in that table for 0.10 per cent carbon and 0.34 per cent manganese, 50,145 lb. per sq. in. (3525.2 kg. per sq. cm) and giving an increase of 830 lb. (58.36 kg) for each 0.01 per cent of carbon and 170 lb. for each 0.01 per cent manganese, that satisfactory results were obtained.

These estimated tensile strengths are given in Table 3 for each increase of 5 points carbon from 0.10 to 0.40 per cent inclusive, and for each increase of 4 points manganese from 0.34 to 0.58 per cent manganese inclusive. For convenience of comparison, the results of the tension tests from Table 1 for the same subdivisions of 5 points of carbon and manganese are given in Table 3, also the differences between the tension tests and estimated tensile strength. The results agree much better than one would expect, and indicate that manganese has a much greater effect than is usually assigned to it.

Table 3—Comparison of Results of Tensile-Strength Tests and Estimated Values of Basic Open-Hearth Steel.

Base used for estimate tensile strength for Webster's values 50,145 pounds per square inch for 0.10 per cent carbon, and 0.34 per cent manganese. Phosphorus content 0.02 per cent in all cases.

Per Cent Carbon	Results	Per Cent Manganese 0 34	0.38	0.42	0.46	0.50	0.54	0.58
		Tensile Strength, Pounds per Square Inch						
0.10	Steel works A	50,145	50,950	51,700	52,440	53,000	53,800	54,600
	Estimated	50,145	50,825	51,505	52,185	52,865	53,545	54,225
	Difference	....	—125	—195	—255	—135	—255	—375
0.15	Steel works A	56,475	56,660	56,800	56,950	57,250	58,010	58,560
	Estimated	54,295	54,975	55,655	56,335	57,015	57,695	58,375
	Difference	—2,180	—1,685	—1,145	—615	—235	—315	—185
0.20	Steel works A	59,300	59,565	59,980	60,570	61,250	62,170	63,030
	Estimated	58,445	59,125	59,805	60,485	61,165	61,845	62,525
	Difference	—855	—440	—175	—85	—85	—325	—505
0.25	Steel works A	61,665	63,120	64,000	64,535	65,200	65,840	66,480
	Estimated	62,595	63,275	63,955	64,635	65,315	65,995	66,675
	Difference	+930	155	45	+100	+115	+155	+195
0.30	Steel works A	64,770	66,290	67,510	68,410	69,250	69,945	70,710
	Estimated	66,745	67,425	68,105	68,785	69,465	70,145	70,825
	Difference	+1,975	+1,235	595	375	+215	+200	+115
0 35	Steel works A	69,930	71,700	72,755	73,215	74,000	74,920	75,510
	Estimated	70,895	71,575	72,255	72,935	73,615	75,295	74,975
	Difference	+965	—125	—500	—280	—385	—625	—535
0.40	Steel works A	73,600	75,200	76,700	78,000	79,000	79,880	81,000
	Estimated	75,045	75,725	76,405	77,085	77,765	78,445	79,125
	Difference	+1,445	+525	—295	—915	—1,235	+1,435	—1,875

Comparison of Steel Works A Tension Tests With Estimated Strengths.

In order to make a thorough comparison between the methods used by steel works A and X with the estimated tensile strengths by the methods of Campbell, Cunningham, and Webster, six tables have been prepared, each covering a range of 40,000 lb. (703.08 kg.) in specified tensile strength. Tables 4 to 7 are for steels of about 0.02 per cent phosphorus and not over 0.031 per cent. Tables 8 and 9, for steels containing 0.06 per cent phosphorus, are given to bring out clearly the actual increase in tensile strength by the different methods used.

The limits of manganese, 0.34 to 0.56 per cent inclusive, are much wider than would be used in practice, but they are so made to show more clearly the effect of manganese when used by steel works A, Campbell and Webster, and how the tensile strengths arrived at compare with the results of steel works X and Cunningham, who do not give it any value.

When taking into consideration all the differences in the six methods used to find the required carbons for tensile strengths called for in the four divisions of the low-phosphorus steels and the two divisions of the higher phosphorus steels, the results agree remarkably well. Any of these methods, by slight modifications to suit the rolling conditions of any mill, could soon be used for the grading of the steel.

These tables were prepared not only for discussion but to induce others to give us similar tables covering their methods used in grading and rolling bessemer steel, basic and acid open-hearth steel and electric steel, also duplex and triplex steels. From a comparison of the methods given for all of these, many important facts would be brought out in the discussion. If any manufacturer does not desire to give full publicity to his methods, they will be submitted to a small committee for a comparison with the other tables and methods given for all of these, many important facts would be brought out in the discussion. If any manufacturer does not desire to give full publicity to his methods, they will be submitted to a small committee for a comparison with the other tables and methods given and a short report of its views on same. In this connection, no doubt all of the factors that have a bearing on the quality of the finished steel will be considered and discussed. It is suggested that particular attention be given to the direct or indirect effects of the recarburization of the metal, also to the stock used, etc.

Particular attention is called to the following from Mr. A. A. Stevenson's discussion of one of the writer's early papers:* "You state that 'the quality of steel depends (1) on its chemical composition; (2) on the treatment it received in the course of manufacture.' I would go a step further, and say that, in my opinion, as far as open-hearth steel is concerned, the physical results, to a certain extent, depend on manipulation of the bath in the furnace.

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*Jnl. Frank. Inst. (January, 1899), 147, 14.

"Concerning the relations between the chemical composition and physical results, I must say I have been somewhat surprised to find how close this relation is. The point in question has been brought out strongly in test work we have recently done on some tires made for a foreign government to a rather difficult specification."

His remarks on the importance of the treatment of steel in the furnace were considerably ahead of the times, but have been fully confirmed since then, and recently it has been found that variations in the working of the blast furnace at times produce undesirable conditions that carry through all the way to the finished steel. The conditions referred to are no doubt due to oxygen in the steel, and it is to be hoped that we will have a full discussion on this question.

Underlying this whole matter are the changes in the structure of steel produced by the heat treatment and work it receives in rolling. These changes are recognized

Table 4—Carbon Limits* for Basic Open-Hearth Steel 7/16 inch Thick; Desired Rolling Limits About 52,500-58,000 Pounds.

Phosphorus content 0.02 per cent; specified ultimate strength 50,000-60,000 pounds.

	Low Limit			High Limit		
	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch
Steel works A	0.12	0.34	52,675	0.15	0.34	56,475
	0.12	0.56	55,850	0.15	0.56	58,320
Campbell	0.12	0.34	52,346	0.15	0.34	55,496
	0.12	0.56	54,210	0.15	0.56	57,360
Webster	0.09	0.34	52,220	0.12	0.34	55,020
	0.09	0.56	55,100	0.12	0.56	57,900
Cunningham	0.10	0.34	52,000	0.16	0.34	58,000
	0.10	0.56	52,000	0.16	0.56	58,000
Steel works X	0.11	0.34	52,000	0.16	0.34	58,000
	0.11	0.56	52,000	0.16	0.56	58,000
Estimated tensile strengths by Webster (See Table 3.)	0.12	0.34	51,805	0.15	0.34	54,295
	0.12	0.56	55,545	0.15	0.56	58,035

Table 5—Carbon Limits* for Basic Open-Hearth Steel 7/16 inch Thick: Desired Rolling Limits About 62,000-68,000 Pounds.

Phosphorus content 0.02 per cent; specified ultimate strength 60,000-70,000 pounds.

	Low Limit			High Limit		
	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch
Steel works A	0.25	0.34	61,665	0.27	0.34	62,905
	0.25	0.56	66,160	0.27	0.56	67,820
Campbell	0.21	0.34	61,796	0.25	0.34	66,002
	0.21	0.56	63,660	0.25	0.56	67,866
Webster	0.20	0.34	62,020	0.24	0.34	65,220
	0.20	0.56	64,900	0.24	0.56	68,100
Cunningham	0.20	0.34	62,000	0.26	0.34	68,000
	0.20	0.56	62,000	0.26	0.56	68,000
Steel works X	0.21	0.34	62,000	0.26	0.34	68,000
	0.21	0.56	62,000	0.26	0.56	68,000
Estimated tensile strengths by Webster (See Table 3)	0.24	0.34	61,765	0.27	0.34	64,255
	0.24	0.56	65,505	0.27	0.56	67,995

Table 6—Carbon Limits* for Basic Open-Hearth Steel 7/16 inch Thick; Desired Rolling Limits About 57,000-63,000 Pounds.

Phosphorus content 0.02 per cent; specified ultimate strength 55,000-65,000 pounds.

	Low Limit			High Limit		
	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch
Steel works A	0.16	0.34	57,040	0.20	0.34	59,300
	0.16	0.56	59,180	0.20	0.56	62,610
Campbell	0.16	0.34	56,546	0.20	0.34	60,746
	0.16	0.56	58,410	0.20	0.56	62,610
Webster	0.14	0.34	57,020	0.18	0.34	60,420
	0.14	0.56	59,900	0.18	0.56	63,300
Cunningham	0.15	0.34	57,000	0.21	0.34	63,000
	0.15	0.56	57,000	0.21	0.56	63,000
Steel works X	0.16	0.34	57,000	0.22	0.34	63,000
	0.16	0.56	57,000	0.22	0.56	63,000
Estimated tensile strengths by Webster (See Table 3.)	0.18	0.34	58,785	0.21	0.34	59,275
	0.18	0.56	60,523	0.21	0.56	63,015

*Carbon limits vary with material rolled and conditions of rolling at different mills.

Table 7—Carbon Limits* for Basic Open-Hearth Steel 7/16 inch Thick; Desired Rolling Limits About 67,000-73,000 Pounds.

Phosphorus content 0.02 per cent; specified ultimate strength 65,000-75,000 pounds.

	Low Limit			High Limit		
	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch
Steel works A	0.32	0.34	66,835	0.33	0.34	67,865
	0.32	0.56	72,295	0.33	0.56	73,290
Campbell	0.26	0.34	67,046	0.30	0.34	71,246
	0.26	0.56	68,910	0.30	0.56	73,110
Webster	0.26	0.34	66,820	0.30	0.34	70.020
	0.26	0.56	69,700	0.30	0.56	72.900
Cunningham	0.25	0.34	67,000	0.31	0.34	73,000
	0.25	0.56	67,000	0.31	0.56	73,000
Steel works X	0.26	0.34	67,000	0.31	0.34	73,000
	0.26	0.56	67,000	0.31	0.56	73,000
Estimated tensile strengths by Webster	0.30	0.34	66,745	0.33	0.34	69,235
(See Table 3.)	0.30	0.56	70,485	0.33	0.56	72.975

Table 8—Carbon Limits* for Basic Open-Hearth Steel 7/16 Inch Thick; Desired Rolling Limits About 57,000-63,000 Pounds.

Phosphorus content 0.06 per cent; specified ultimate strength 55,000-65,000 pounds.

	Low Limit			High Limit		
	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch
Steel works A	0.12	0.34	56,675	0.15	0.34	60,475
	0.12	0.56	59,850	0.15	0.56	62.320
Campbell	0.12	0.34	56,546	0.16	0.34	60,746
	0.12	0.56	58,416	0.16	0.56	62,610
Webster	0.10	0.34	57,020	0.13	0.34	60,020
	0.10	0.56	59,900	0.13	0.56	62.900
Cunningham	0.11	0.34	57,000	0.17	0.34	63,000
	0.11	0.56	57,000	0.17	0.56	63,000
Steel works X	0.10	0.34	57,000	0.16	0.34	63,000
	0.10	0.56	57,000	0.16	0.56	63,000
Estimated tensile strengths by Webster	0.13	0.34	56,635	0.16	0.34	59,125
(See Table 3.)	0.13	0.56	60,375	0.16	0.56	62.875

Table 9—Carbon Limits* for Basic Open-Hearth Steel 7/16 Inch Thick; Desired Rolling Limits About 67,000-73,000 Pounds.

Phosphorus content 0.06 per cent; specified ultimate strength 65,000-75,000 pounds.

	Low Limit			High Limit		
	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch	Per Cent Carbon	Per Cent Manganese	Ultimate Strength, Pounds per Square Inch
Steel works A	0.27	0.34	66,905	0.28	0.34	67,530
	0.27	0.56	71,820	0.28	0.56	72,655
Campbell	0.22	0.34	67,046	0.26	0.34	71,246
	0.22	0.56	68,910	0.26	0.56	73,110
Webster	0.21	0.34	66,820	0.25	0.34	70,020
	0.21	0.56	69,700	0.25	0.56	72,900
Cunningham	0.21	0.34	67,000	0.27	0.34	73.000
	0.21	0.56	67.000	0.27	0.56	73,000
Steel works X	0.20	0.34	67.000	0.25	0.34	73,000
	0.20	0.56	67;000	0.25	0.56	73.000
Estimated tensile strengths by Webster	0.25	0.34	66,595	0.28	0.34	69.085
(See Table 3.)	0.25	0.56	70,335	0.28	0.56	72,825

*Carbon limits vary with material rolled and conditions of rolling at different mills.

in the ordinary fractures and in some cases in the polished and etched surfaces without the use of a glass. Low-power hand glasses have been used to advantage, but there is yet a wide and promising field of microscopical research work on low-carbon structural steel.

In 1894, the writer first called attention to this important point and endeavored to show that at times the chemical composition of steel was of less importance than the poor structure due to improper treatment in heating and rolling. His remarks were in part as follows:†

"When rolling heavy steel plates, trouble is often caused by finishing them at too high a temperature, which gives a material with crystalline fracture, poor reduction of area, and poor bends. In order to guard against this and control the finishing temperature we use very light drafts in rolling, and produce as good results in heavy plates as in the light ones. Too much importance cannot be given to the heat treatment of steel."

The writer in 1904 in a discussion of Mr. Campbell's paper said:‡

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†Jnl. Iron & Steel Inst. (I, 1894), 45, 335.

‡Jnl. Iron & Steel Inst. (II, 1904), 66, 65.

"I agree with Mr. Campbell in that it is not necessary to take the microstructure of the steel into consideration from the standpoint of his investigation. Yet anything that will in any way assist in controlling the heat treatment of the steel should be looked into. In the ordinary microscopical work they have not tied up the fractures of a nicked and broken piece of steel, as we know it, with the microstructure of the same steel. This step from the old to the new has long been needed, and I now desire to call attention to a method of slight etching and low magnification with a hand-glass that is very promising. It looks as though by this method we will be able to tie up the fractures of steel of, say, 0.50 carbon and under. These pieces are from the same bar of 0.35 carbon acid open-hearth steel. One piece was overheated and shows the large coarse structure; the other piece was overheated and then annealed; it shows a much finer structure. A test of this kind would be useful in the case of large driving axles, as a small spot could be polished and etched; the glass would show if the steel had been finished at too high a temperature in forging; that is, if it had too large a grain and was in a dangerous condition. This method of investigation is offered at this time as a suggestion in the hopes that others will take it up and improve it."

The first practical use in examining large forgings as suggested above was by Colonel W. P. Barbo during the war, and he has kindly given me the following describing the results of their work:

"During 1917, Mr. Wm. R. Webster, in conversation with me, showed that in his practice, he had recognized a need which we had but recently developed in our field work, in production of high-quality forgings for war purposes. This need was to discover on polished surfaces, the nature and extent, as well as the probable seriousness of solid non-metallic inclusions which had come to light on finished surfaces during manufacture.

"Mr. Webster then contributed to the service of the Government, through me, a small portable microscope, working to approximately 50 diameters (?), and which could easily be dismounted and packed in a grip, carried to any location in the field, and readily set up on a large forging under examination, and proved its great usefulness in determining the seriousness of such inclusions in a manner which in no way interfered with the future usefulness of the piece.

Table 10—Effects of Carbon on Tensile Strength, According to Howe.

Per Cent Carbon	Lower Limit, Pounds per Square Inch	One-Quarter Increase, Pounds per Square Inch	One-Half Increase, Pounds per Square Inch	Three-Quarters Increase, Pounds per Square Inch	Upper Limit, Pounds per Square Inch
0.05	50,000	54,000	58,000	62,000	66,000
0.10	50,000	55,000	60,000	65,000	70,000
0.15	55,000	60,000	65,000	70,000	75,000
0.20	60,000	65,000	70,000	75,000	80,000
0.25	62,500	68,000	73,750	79,375	85,000
0.30	65,000	71,250	77,700	83,750	90,000
0.35	67,500	74,375	81,520	88,125	95,000
0.40	70,000	77,500	85,000	92,500	100,000
Effect of 0.01 per cent carbon	666	750	833	917	1,000

"Some such apparatus as that which was provided by Mr. Webster, out of his large previous experience, would be of great use if much more extensively applied in practical inspection and works-control operations."

No paper of this kind would be complete without referring to Doctor Howe's views on the effect of carbon on the ultimate strength of steel, given in "Metallurgy of Steel" in 1892, and without trying to solve the problem he gave at that time. For several years this problem appeared difficult to the writer, but the advances in metallurgy of steel since 1892 have practically solved it. The tables of averages of the ¾-in. round tests of Steel Works A more than cover the wide limits for carbons under 0.40 per cent, without taking into account the changes in tensile strength due to thickness of material rolled, and the varying limits of carbon found necessary to secure the same tensile strength in all thickness of material rolled from the same heat of steel. While not used, this greatly simplified the problem. Doctor Howe in "Metallurgy of Steel" states: "While we cannot accurately qualify the effects of carbon, I believe that for ordinary unhardened merchantable steel, the tensile strength is likely to lie between the following pretty wide limits:

Carbon Per Cent	Lower Limit	Upper Limit	Differences by Webster
0.05	50,000	66,000	16,000
0.10	50,000	70,000	20,000
0.15	55,000	75,000	20,000
0.20	60,000	80,000	20,000
0.30	65,000	90,000	25,000
0.40	70,000	100,000	30,000
0.50	75,000	110,000	30,000
0.60	80,000	120,000	40,000
0.80	90,000	150,000	60,000
1.00	90,000	170,000	80,000
1.30	90,000	115,000	25,000

For the consideration of these limits to be expected in the lower carbons from 0.05 to 0.40 per cent carbon inclusive, the upper and lower limits have been subdivided as shown in Table 10, Howe. In Table 10 is given a subdivision of these limits from 0.05 to 0.40 per cent carbon, inclusive. The second column gives the lower limits and the last column gives the upper limits. The third column is one-quarter of the difference of increase between the upper and lower limits; the fourth column is one-half of this increase; and the fifth column three-quarters of the increase. The upper and lower limits for 0.25 per cent carbon and 0.35 per cent carbon have been added to the limits given by Doctor Howe for convenience of investigation; they are merely the limits between the values that he gives for 0.20, 0.30 and 0.40 per cent carbon. At the foot of each column is given the average effect of 0.01 per cent carbon.

In Table 11 are given the nearest values of steel works A corresponding to the subdivisions of Doctor Howe's values. These values are given with an increase of two points of phosphorus from 0.02 to 0.08 per cent in basic open-hearth steel; the last column is for bessemer steel containing 0.10 per cent phosphorus. As their tables do not give 0.05 per cent carbon, this table starts with 0.10 per cent carbon. The average effects for 0.01 per cent carbon are given at the bottom of each column.

It is unreasonable to expect that the values of carbon and other elements that apply to the lower steels can be applied equally well to the higher steel, as the difficulties in meeting the requirements of specifications increase as the tensile strength increases. This is due to reductions in rolling and finishing temperature having a greater effect on the higher carbon steels. An exception to this was shown about twenty years ago by Mr. A. A. Stevenson, then manager of the Standard Steel Works, who had been interested in the writer's work. He rolled successfully several export orders of locomotive tires, subject to both tension and deflection tests, from heats of acid open-hearth steel graded from their chemical composition by Webster's values. He paid great attention to the reductions in rolling and finishing temperatures of these tires, which met perfectly all the tension and deflection tests called for by the specifications on the unannealed tires. This showed that where all the rolling conditions could be controlled the relation between the chemical composition and mechanical properties could be relied on for steels considerably higher in tensile strength and carbon than the usual structural steel.

The results given and the comparisons made in Tables 10, 11 and 12, with other data given, puts the relation between the chemical composition of steel and its physical properties on a much firmer basis than formerly when carbon alone was expected to account for practically all of the differences in the tensile strength of steel.

For convenience of comparison, in Table 12 the two tables are combined, Howe's values being given on the upper lines and Steel Works A on the lower lines in each subdivision. The results are much closer than was to be expected and is a step toward the solution of the problem given by Doctor Howe in 1892.

Table 12 shows that the average effect of 0.01 per cent carbon from 0.10 to 0.40 per cent increases with the increase of phosphorus and manganese.

Table 11—Effects of Carbon on Tensile Strength, According to Steel Works A

Per Cent Carbon	Tensile Strength, in Pounds per Square Inch, With— P 0.02% Mn 0.34%	P 0.04% Mn 0.50%	P 0.06% Mn 0.72%	P 0.08% Mn 0.80%	P 0.10% Mn 0.94%
0.10	50,140	55,000	60,090	63,000	69,540
0.15	56,475	59,250	65,200	68,000	75,080
0.20	59,300	63,250	69,400	72,700	81,820
0.25	61,665	67,200	72,950	77,770	85,600
0.30	64,770	71,250	78,400	82,000	89,960
0.35	69,930	74,580	82,450	86,000	93,460
0.40	73,600	78,000	89,460	93,000	100,160
Effect of 0.01 per cent carbon	782	800	979	1,000	1,054

Table 12—Comparison of Results Obtained by Howe and Steel Works A.

	Per Cent Carbon	Tensile Strength, Pounds per Square Inch With— P 0.02% Mn 0.34%	P 0.04% Mn 0.50%	P 0.06% Mn 0.72%	P 0.08% Mn 0.80%	P 0.10% Mn 0.94%
Howe	0.05	50,000	54,000	58,000	62,000	66,000
Steel works A	....	....	....	....	....	....
Howe	0.10	50,000	55,000	60,000	65,000	70,000
Steel works A	0.10	50,140	55,000	60,090	63,000	69,540
Howe	0.15	55,000	60,000	65,000	70,000	75,000
Steel works A	0.15	56,475	59,250	65,200	68,000	75,080
Howe	0.20	60,000	65,000	70,000	75,000	80,000
Steel works A	0.20	59,300	63,250	69,400	72,700	81,820
Howe	0.25	62,500	68,000	73,750	79,375	85,000
Steel works A	0.25	61,665	67,200	72,950	77,700	85,600
Howe	0.30	65,000	71,250	77,700	83,750	90,000
Steel works A	0.30	64,770	71,250	78,400	82,000	89,960
Howe	0.35	67,500	74,375	81,520	88,125	95,000
Steel works A	0.35	69,930	76,000	82,450	86,000	93,460
Howe	0.40	70,000	77,500	85,000	92,500	100,000
Steel works A	0.40	73,600	79,000	89,460	93,000	100,160
Average effect of 0.01 per cent carbon:						
Howe	....	666	750	833	917	1,000
Steel works A	....	782	800	979	1,000	1,054

PURCHASING AGENTS NOMINATE OFFICERS

It is somewhat unusual for the nominating committee of any national organization such as the National Association of Purchasing Agents to name only one slate for re-election and that slate to incorporate, without exception, the entire board as it now stands. Yet this is exactly what happened when the nominating committee of the N. A. P. A. submitted the following report of their deliberations:

For President—W. L. Chandler, Dodge Sales and Engineering Co., Mishawaka, Indiana.

First Vice-President—A. H. Reinhardt, Poole Bros., Chicago, Ill.

Second Vice-President—T. P. Webster, Dominion Textile Co., Montreal, Canada.

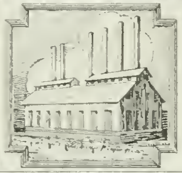
Third Vice-President—A. V. Howland, Tileston & Hollingsworth Co., Boston, Mass.

Fourth Vice-President—S. F. Woodbury, Williamette Iron & Steel Works, Portland, Oregon.

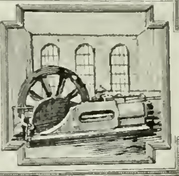
Fifth Vice-President—D. E. Ferguson, H. K. Porter Co., Pittsburgh, Pa.

Treasurer, W. J. Gamble, Vulcan Steam Forging Co., Buffalo, N. Y.

Secretary—L. F. Boffey, 19 Park Place, New York, N. Y.



STEAM POWER DEPARTMENT



Boiler Water Treatment Plants

Specifications for Ideal Water Purification Plants — Correcting Bad Water — Determination of Hardness — Scale and Corrosion.

By ROBERT JUNE, M.E.

HAVE you ever visited a salt plant? If so, you must have watched with interest the processes of evaporation in the salt pans. The brine enters the pans as a clear liquid, but as soon as heat is applied the water begins to disappear in steam, and the salts are deposited. As you watched the deposits of salts increase, did it occur to you that an identical process to that going on before you was constantly going forward in your boilers?

In the case of the boiler, the entering water is not loaded with the same high percentage of salt, to be sure, but the quantity of impurities is higher than is generally appreciated, and when you consider that there are literally many tons of water evaporated in the average boiler every day, and all the various salts and other impurities carried into the boiler remain there until some definite action is taken to effect their removal, the fact becomes apparent that in dealing adequately with the impurities in water, we have a problem of real magnitude.

The importance of boiler water treatment is, indeed, not generally realized, because the size of the operating losses resulting from failure to remove or neutralize impurities in the feed water is not understood. These losses are caused by the formation of scale which reduces boiler efficiency and capacity, and by the pitting and corrosion of boiler tubes, which makes necessary their replacement.

Trouble Resulting From the Use of Bad Water.

In addition to causing scaling and corrosion, bad water causes foaming or priming. These troubles are self-evident. There are other troubles, however, which are due to bad water and which are not so apparent. The good or bad condition of pump valves, and connections and feed lines, is largely dependent upon the quality of the water used, a fact which becomes evident when we suddenly lose the feed to a boiler and perhaps the boiler, or a good part of it. Nor do we always directly connect the breaking of a piston rod, cross head, or cylinder head with excess causticity or precipitates mixed with steam. Other losses which may often be traced to bad water are gradually increased steam consumption, excessive wear on packings and moving engine parts, and increased lubrication.

While these losses may not always be directly traced back to boiler feed, it is a fact that when our water is constantly purified there is very much less likelihood of these troubles occurring.

Correcting Bad Water.

The neutralization or elimination of impurities in feed water may be effected by one or more of the following methods:

- I. By chemical means.
    - a. Boiler compounds.
    - b. Water softening plants.
- II. By mechanical means.
    - a. Tube cleaners.
    - b. Blow off.
    - c. Filter plants.
- III. By thermal treatment.
    - a. Feed water heaters.
    - b. Distillation plants.

Before discussing these means of removing trouble, let us inquire further into the sources of our difficulties. We find that our troubles and their causes are as follows:

Scaling—caused by the presence of sediment, mud, clay, readily soluble salts, bi-carbonate of magnesia, lime, iron, sulphate of lime, organic matter, etc.

Corrosion—caused by the presence of grease, organic matter, chloride or sulphate of magnesium, sugar, acid, dissolved carbonic and oxygen, and also by electrolytic action.

Priming—caused by the presence of sewage, alkilis and carbonate of soda in large quantities.

F. J. Crolius, steam engineer, of the Carnegie Steel Company, classifies the various inorganic impurities in the manner shown in Table 1.

Table 1.

Free CO_2 — which is corrosive	are negative hardness, but not scaling
Na HCO_2 — which is not corrosive	
$CaH_2(CO3)_2$	are temporary hardness, but non scaling
$Mgh_2(CO_3)_2$	
$FeH_2(CO_3)_2$	
$MgSO_4$	non-corrosive, are permanent hardness and scale forming
$CaSO_4$	
$Fe_2(SO_4)_3$	All corrosive, are permanent hardness and scale forming except H_2SO_4
$Al_2(SO_4)_2$	
$CuSo_4$	
H_2SO_4	

With the addition of chlorine, the combinations given in the table cause most of our troubles. It is evident that the causes of so-called permanent hardness fall entirely within the sulphate range and as a matter of fact most of our efforts must be directed towards the reduction of sulphates.

The principal scale forming offenders, $CaSO_4$ and $MgSO_4$, are non-corrosive, and the simplest procedure is to convert them to $NaSO_4$ and Ca or Mg carbonates, which are insolubles, by the addition of sodium. The sulphates of iron, aluminum and copper are usually so low that they can be ignored. This is fortunate, as their removal or conversion are not readily accomplished and when necessary usually requries expensive treatment.

Determination of Hardness.

A 100-cc (cubic centimeter) sample of water to be tested is put in a 250-cc bottle and a standard soap solution (this may be obtained from chemical dealers) run in 0.2-cc at a time, the bottle being shaken vigorously after each addition of the soap solution. Finally a lather is produced that will persist for at least five minutes, and then the volume of soap solution used in cc gives the degrees "U. S." hardness. One degree "U. S.' hardness is equivalent to 1 grain of calcium carbonate per U. S. gallon (1 part in 58,349).

Professor Gebhardt employs the following factors for specifying the hardness of water in terms of calcium carbonate per U. S. gallon:

Magnesium carbonate	× 1.19	= hardness as calcium carbonate, grains per U. S. gallon or U. S. deg.
Magnesium sulphate	× 0.833	
Calcium sulphate	× 0.735	
Magnesium chloride	× 1.05	
Calcium chloride	× 0.901	

It is impossible to judge the quality of feed water merely by the grains of solids per gallon since a large amount of soluble salt such as sodium chloride will not be as deleterious as a very small amount of calcium sulphate.

The scale of hardness usually accepted (grains of dissolved salts per U. S. gallon) is as follows: Soft water, 1 to 10; moderately hard water, 10 to 20; very hard water, above 25.

The following is a rough rating according to the number of grains of incrusting solids per United States gallon:

Less than 8 grains	very good
12 to 15 grains	good
15 to 20 grains	fair
20 to 30 grains	bad
Over 30 grains	very bad

This applies to calcium carbonate, magnesium carbonate, and magnesium chloride. For water containing sulphate of calcium and magnesium, divide the first column by 4 for the same rating.

The limiting factor in deciding whether a water carrying a large amount of soluble salts may be used for boiler feed purposes is the amount of blowing down necessary to keep the degree of concentration within the limits found by experience.

By the use of proper methods we may accomplish the complete removal of permanent hardness, oil, grease and suspended matter, and may neutralize all their acids. The feed water may be so purified as to contain less than 1½ grains per gallon of hardness, due to calcium carbonate and magnesium hydroxide. The total of encrusting substances, including silica, may be so reduced as to be less than 2 grains per gallon. This is the standard of purification which can usually be obtained and towards which we should work.

Scale.

The character of scale varies from that of a porous, friable crust, to a dense very hard coating. The amount of impurities present in the water cannot be used as a basis for pre-determining the amount of scale which will be formed, as this depends on the type of boiler, rate of driving and the nature of the scale forming ingredients.

In Table 2 we have the results of a number of tests made on locomotive boiler tubes with different thicknesses and character of scale. The variations in conductivity show the futility of basing any calculations on the thickness of scale. Thus test No. 1 shows a decrease of conductivity of 9.1 per cent for a scale of 0.02 inch thick, while No. 16 shows a decrease of only 6.75 per cent for a scale over 6½ times as thick. In each case the scale was even, hard and dense.

Table 2.

INFLUENCE OF SCALE ON HEAT TRANSMISSION*

No.	Thickness of Scale, Inches	Character of Scale	Decrease in Conductivity, Due to Scale Per Cent
1	.02	Hard, dense	9.1
2	.02	Hard	2.02
3	.033	Soft	4.3
4	.033	Very hard	3.5
5	.038	Medium	4.03
6	.04	Soft, porous	6.82
7	.04	Hard, dense	3.07
8	.042	Very soft	9.54
9	.047	Hard	2.75
10	.065	Medium	2.39
11	.07	Soft	2.38
12	.07	Hard	4.43
13	.085	Soft, porous	19.0
14	.089	Very soft	4.95
15	.11	Hard, porous	16.73
16	.13	Hard, dense	6.75

The presence of scale, however, does cause material reduction in the heating surface, and in the volume of water held in the boilers. Thus a 4-inch boiler tube, when clean, has an internal area of 141 square inches per foot of length, but should this tube become lined with ¼ inch of scale its area per foot of length is reduced to 122 square inches. We thus find that a quarter inch of scale reduces the actual heating surface by about 11 per cent and the volume of water by about 12 per cent. Furthermore, the reduced area of the tubes tends to retard circulation.

Overheating of boiler tubes is the result of the presence of scale. When the deposit is heavy the tubes in the hottest passes of the boiler may become so hot that the pressure will bulge the metal to such an extent that the bursted tube has the appearance of having been drawn. Overheating, even to a moderate degree, may cause gradual crystallization of the steel so that it eventually becomes brittle and can be broken like ordinary castings. The bursting of tubes is one of the most dangerous factors connected with the operation of water tube boilers and as it can always be traced to the presence of scale or oil on the internal surfaces, it follows that from the standpoint of safety and economy such conditions should not be tolerated.

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*Tests made at University of Illinois.

Foaming and Priming.

When foaming occurs it can usually be traced to the presence of one or more of the following impurities: emulsified oil and grease, soluble organic matter, and silt in suspension. It may, however, be due to improper methods of handling the boiler, such as irregularity of load, improper firing and feeding, neglect to make periodic changes of water within the boiler, or to improper design of boiler, wrong arrangement of steam piping, incorrect water spaces or steam liberating area.

It is frequently claimed by operating engineers that the direct cause of priming and foaming in boilers is the presence of sodium salts in the feed water and of the sodium salts, sodium carbonate or soda ash is the one most often charged with causing foaming. The trouble in such cases, however, is not due to the soda ash, but to the wrong application of it. It will usually be found that where foaming occurs with soda ash, that no provision is made of the removal of precipitates formed by its reaction with the scale forming substances in the water. The result is the water becomes so befouled with impurities that priming and foaming occur.

Foaming may also be caused by the introduction of soda ash in an open heater which receives more or less animal oil with the exhaust, and the mixture of this organic oil with water containing sodium carbonate produces a soapy emulsion in addition to lime and magnesium precipitate.

Corrosion.

Corrosion is evidenced by small pits or depressions and by large cup-shaped hollows on the metal surface, and occasionally by a considerable destruction of a large portion of the surface. Carbonic acid gas, occluded oxygen, sodium, calcium and magnesium chlorides are common causes of corrosion. Magnesium and calcium chlorides are very pernicious in that they produce free hydrochloric acid on hydrolysis. Corrosion is also found in boilers using a high percentage of condensate or distilled water.

Where pitting and corrosion occur under deposits of scale, the trouble is usually due either to the presence of free acid in the water or to the liberation of acid by the dissociation of magnesium compounds or other substances.

The corrosive effect of sulphuric acid in the boiler follows an unending cycle of first dissolving iron and then precipitating it, liberating the acid which again immediately dissolves more metal. As a consequence of this condition a small amount of sulphuric acid within the boiler keeps up a constant attack on the metal and this corrosive action may occur with a boiler feed water in which no free acid is present when delivered to the boiler.

Pitting and corrosion, when found in equal intensity both above and below the water line, may be attributed to the presence of hydrochloric acid, which is volatile at boiler temperatures. While hydrochloric acid is not found in feed water it may be formed in the boiler from the decomposition of the chlorides of calcium or magnesium.

Sources of Water Supply.

Boiler feed water is obtained from any one of four principal sources, as follows:

1. Condensate.
2. Bays or lakes of fresh water.
3. Flowing streams.
4. Wells.

There is a fifth source of supply, city water, which, while it originates in one of the four sources listed above, demands separate consideration because of the treatment this water undergoes to fit it for public use.

Condensate. Condensate is certainly the ideal form of feed—a fact nowhere better evidenced than in the design of our modern central stations. Every effort should be made in all plants without exception to see that not a pound of exhaust steam from auxiliaries, pumps, stoker engines, traps, etc., is allowed to go to waste.

Lakes and Bays. Lake water has the merit of uniformity, and when a practical method of purification has once been developed, a standard of practice can be set up and maintained year after year. Lake water is almost invariably alkaline, seldom badly bi-carbonate, and in general presents no serious problem.

Flowing Streams. With rivers we have an individual problem as one stream is acid and the next alkaline. Moreover, the number of parts of impurities to the gallon varies not only from season to season, but daily and hourly. There is one redeeming feature, however, in that this variation in the quantity of impurities does not extend to the ratio of the impurities one with another. This means that in dealing with river water, we can count on the same relative percentages of impurities one with another at all times, and this greatly simplifies our problem.

Wells. Wells are seldom used for boiler feed when other sources are available. Generally speaking they contain a concentration of impurities, and while the water is almost uniform in its analysis, still the quantities of impurities to be disposed of are so great that adequate treatment is a real problem.

City Water. City supply while pure enough for drinking purposes is usually a dangerous proposition for boiler feed. It is very apt to contain chlorine, which presents a serious problem in itself. If it has been filtered, the organic matter has largely been removed, but the scale forming salts remain.

Specifications for Ideal Water Purification Plant.

The ideal water purification plant should measure up to the following specifications:

1. It should produce a water with which can be maintained an internal boiler condition of pre-determined alkalinity, without bi-carbonate, without scale formation, without corrosion and without foaming.
2. There should be no deposits in the feed lines and pumps and no undue wear on valves and moving parts.
3. There should be no bad effects from carried over steam to prime movers, packing or lubrication, or to the product, if steam is used for industrial purposes.
4. It should involve a minimum of expert attention and should require only simple standard mechanical elements, using standard reagents and standard indicators.
5. Filters should not be required.
6. Its capacity should be unlimited and the cost low.

In a later paper we will discuss in detail the individual methods of water purification.

Development of A Powdered Coal Plant

Some Controlling Features in the Use of Powdered Coal—Many of These Have a Direct Bearing on the Economical Operation of the Plant.

By CHARLES LONGENECKER.

THE principal reasons for the substitution of powdered coal for other fuels is the saving in fuel cost and in labor. These savings are, in the majority of cases, realized but in some cases the saving, while very substantial is not as large as expected. This is generally due to the failure to appreciate the significance of features which at first sight are not recognized as vitally important or it may be due to an incorrect valuation of certain of the physical characteristics involved in the success of the undertaking.

Where there are so many variables and where the "human factor" is such a controlling one, it is extremely difficult at times to appraise each factor at its true worth. Some factors appear of greater significance than warranted while others, seemingly trivial, on development, assume an importance never imagined. It is this feature which adds value to experience and by experience alone is it possible to truly balance those controlling features which arise in fuel and furnace engineering, as well as in other classes of engineering. For this reason, as well as others, it is well to look to engineers experienced in the work before undertaking an installation of the kind under discussion.

The features then to be considered, as having a direct bearing on the economical operation of a plant are the following:

1. The grade of coal.
2. Motive power.
3. Equipment.
4. Furnaces in which the coal is burned.
5. The personal factor.
6. The per cent of time the plant is operated.
7. Output of the furnaces.

Fixed charges are not considered as it is only plant operation which is under discussion. These charges, too, are variables for each plant and not of interest as purely engineering topics.

The Grade of Coal.

Before designing a plant it is absolutely necessary to know the analysis and physical characteristics of the coal to be supplied. This is imperative as the quantity of coal handled will depend upon its Btu. content and the manner in which it is prepared on other characteristics. Also guarantees covering the machinery will be based on these features. The coal can vary within certain limits as to moisture, volatile and ash content, but once a certain coal has been used there should be no radical departure from this grade. Thus should a coal of, say 13,000 Btu. content be burned steadily and then without warning a coal of 11,000 Btu. be put in the lines it is most likely that the operation of the system would be greatly disturbed with a consequent disruption of operating routine.

The "moisture content" is certainly a controlling feature especially in the influence it exerts in the preparation of the coal. There is at present much discussion as to whether it is necessary to dry coal before pulverizing it. The answer to this question will depend on the particular coal being considered. Where all the coal is taken direct from the mine to the coal plant, as is the case where the mine and plant are relatively close to each other, there will be little need for a dryer. This also applies where the moisture content of the coal as received is very low. But where the coal is hauled long distances and is liable to be received in a "water soaked" condition the installation of a dryer is advisable. The characteristics of Eastern and Mid-Western coals are different and where it may not be necessary to dry an Eastern coal it may be absolutely necessary to dry a Western or Mid-Western coal. It is very hard to give specific rules governing this feature as the drying of coals must be in accordance with the characteristics of the particular one to be furnished. Quite a latitude is permissible, in the analysis of the coal, when burned as a powder but the fact is frequently overlooked that a poor grade of coal will not give the results that can be expected from the better grades. There is no way whereby a greater percentage of the heat value of any coal can be released than by burning it pulverized, when burned under the proper conditions. But it must be realized that the original heat content, as expressed in Btus., determines the upper limit and the method of burning, however perfect, cannot raise this limit. Results will be secured in proportion to the coal used, other conditions being equal. Experience has taught that it generally pays to purchase a good quality of coal rather than the inferior grades and a coal which costs, says a dollar a ton more than another grade, may give results which will ultimately assure a saving in heating cost of two or three dollars over that obtained from the cheaper grade. Of course it is possible to reverse this condition if the furnace conditions are not right which would be the case if the cheaper coal is burned more efficiently. Other conditions being equal it will be found, in the majority of cases, that the most economical results are not secured by using the lowest grades of coal.

By powdering coal it is possible to utilize some grades, very low in heat value, which cannot be burned economically otherwise. Thus some lignites and peats are being utilized in this form and the efficiencies obtained are far higher than can be realized where other methods of burning are employed.

The mere act of pulverizing will not create a valuable heating agent out of any inferior grade of coal unless that coal has the inherent heat value. The act of pulverizing changes the physical state only and unfortunately by no form of necromancy is it possible to put heating power into a substance where none originally existed. The change in form does give value—"form value"—so that it is possible to burn the coal with the greatest efficiency.

Anthracite coal, due to the low volatile content, and abrasiveness presents difficulties which are not present in bituminous. There can be no question as to its heat content, where the ash content is average, but so far it has not proved as satisfactory as bituminous coal.

For open hearth furnaces it has been found that the best grade of coal obtainable is the most economical. This coal is one low in ash and sulphur and high in volatile such as the Elkhorn coal of Kentucky or other coals of like analysis.

During the war, when it was extremely hard to get deliveries of particular grades of coal, and at times to get any, the supply to the furnaces was liable to fluctuate from day to day and there was no alternative but to accept conditions with the best grace possible. This necessitated more alertness on the part of the furnace operator but by simple adjustments it was possible for him to get the conditions which he desired as far as output is concerned. The flexibility of a powdered coal system is one of its strong features as it lends itself to rapid adjustments to suit the variations which arise and which cannot always be foreseen.

The "moral" to the foregoing is that the cheapest grades of coal are not always the most economical when the final heating cost is computed.

Motive Power.

Here the desired datum is uniform conditions. A change in voltage will cause a change in motor speeds and this in turn will alter the feed of coal to the furnaces. One instance came to the attention of the writer. Here the power was furnished by a "service" company and for certain reasons the fluctuations were extremely wide and hence it was practically impossible to keep the coal supply to the furnaces steady. It is easy to appreciate the ill effects following such a condition. Fortunately this defect is not frequently met and in most cases there is no need for complaint.

Equipment.

Powdered coal equipment has been very well standardized and knowing the conditions prevailing engineers should have no great trouble selecting the machinery best suited to the conditions to be met. Very frequently where difficulties arise it is due to the failure to correctly analyze and properly visualize the particular conditions pertaining to the plant where the installation is to be made. Whatever the class of fuel, there are very few plants where the requirements are similar in all details and the differences existing must be reckoned with.

In deciding on the requirements of a plant the proper place to start is at the furnaces and work from this to the preparing and distributing equipment. When the amount of coal to be consumed has been determined the capacity of the pulverizing and auxiliary equipment is readily found. Of course it is assumed that the grade of coal to be burned has already been decided upon. In this connection the particular class of metallurgical operation—using the term in a broad sense—to be carried out must be given consideration. The guarantees covering the performance of coal handling machinery are based on the class of coal to be handled—dried, pulverized and distributed and hence this should be stipulated.

The various pieces of machinery needed for a complete installation have been so well perfected that there is little cause for apprehension as to their operation. The important feature in this regard is to secure the most approved layout and equipment for economical operation. Manufactures of this machinery are continually looking for improvements and there is always a trend towards the reduction in power required to drive the different pieces of apparatus. Keeping in mind the fact that the history of powdered coal has been confined to the last eight years, as it relates to industrial furnaces, it will be recognized that the progress in that time has been most commendable.

Furnaces.

Granted that the coal has been properly prepared and delivered to the furnaces the successful burning of it is absolutley essential to assure the success of the undertaking. All too frequently the furnace has been a much understood piece of equipment. It has not been given the standing it should have. Again in some instances a collection of brick, steel and cast iron has had conferred upon it the name "furnace" when it certainly does not merit such an exalted term if heating efficiency is taken as a standard. Due to the fact that it is possible to heat material in a fairly satisfactory manner in most any type of furnace efforts are not made to go beyond this degree of satisfaction but to be content. This does not apply to the burning of powdered coal especially but to furnaces in which other fuels are burned as well. The desire here is not to give a definition to the word "furnace" but to emphasize the bearing it has in carrying out the object in substituting powdered coal, viz: a reduction in the fuel cost.

In some of the earlier installations, it must be said in justice, that experience had been too scanty to disclose many of the errors in furnace construction. Today there is little excuse to offer where errors are committed but naturally there is the desire of always improving on past performances.

Where powdered coal is applied to boilers, hand or stoker fired, there is no question but that the furnace construction must be altered completely. In changing the furnace for this fuel it is made with a greater volume. This alteration, increase in furnace volume, is one which would be beneficial to many installations which are stoker fired, or hand fired, as too often not enough combustion space is provided and the gases have not time enough for complete combustion.

The tendency to economize in building furnaces is, at times, carried too far and for the sake of a small saving in installation cost hundreds of dollars are wasted in fuel. As a general rule in applying powdered coal the combustion space is increased in volume. It invariably follows when such an increase is made and the original fuel is again burned in this enlarged combustion chamber far better results are obtained as compared with the results secured in the old setting. In one case where natural gas had been surplanted the saving in heat secured with powdered coal was equal to one-half of the heating power of the natural gas. Tests showed that the gas was only partly consumed. When powdered coal is not being consumed completely it is most evident to the eye and no instruments are needed to indicate the lack of air. If too much air is supplied then instruments are of service but an experienced operator will be able to burn coal in this form very efficiently due to the results, up to a certain point, being so apparent to the eye.

Stress is to be laid on the point that besides a low priced fuel of high Btu. content, as far as can be obtained, there must be a furnace capable of utilizing the fuel to a high degree of efficiency. Where one fuel surplants another and the furnace is unchanged the saving will be reckoned on the difference in the cost of the fuel, other features being equal. But if besides this saving an additional one is realized by better heating conditions, which means a less Btu. expenditure, a twofold economy is affected.

Due to the low price of coal oil and gas there has been little incentive to devote much money towards improving the design and operation of existing furnaces but we are approaching a time, if it is not already here, when greater attention must be given to improved furnace construction. Refractories too are not as low as they were and repairs are higher so that the aim must be to reduce this cost per unit of material heated. If more attention is given to this feature of plant maintenance managers will be able to keep the heating cost within reasonable limits compared to that which obtained some years ago.

The question of the "human equation," in connection with furnace operation, is always a difficult one and will probably always so remain. In some instances the breaking of a precedent has aroused some resentment but in the majority of cases when the workman appreciates that the change will work to his benefit there is usually active coöperation. The aim has been to so equip furnaces that the operation with powdered coal will not differ materially for that in vogue before the change was made.

The percent of time a plant is in operation vitally influences the cost of operation. The greatest saving is made when the whole coal handling plant is operated at maximum capacity and naturally where only part time operation is carried on the savings will be proportionately decreased. This is a factor that cannot be reckoned with as it is controlled by conditions on which there is no method of reckoning.

The output of the furnaces also has a decided influence on the cost sheet as the greater the output the less the cost per unit of material heated. This is another feature which is dependent on business conditions, or orders received, but has no bearing on the way the plant is operated. Here consideration is given only to the time element as influenced by product to be turned out. The operation of the furnace will be diminished, in output, when orders for material heated in the furnace fall off.

New Industrial Oil Burner Creates Interest

Due to the Shortage of Natural Gas In Many Cities, for Industrial Purposes, Oil Is Used as the Principle Substitute for Heating—New Burner as Applied to a Forging Furnace.

THE Anderson-Garner-Shaner oil burning apparatus is an invention which arose as a necessity to meet industrial and domestic heating requirements at times when there are shortages in the natural gas supplies. It is a general practice in Pittsburgh, Cleveland, Buffalo, Wheeling, Cincinnati and Columbus to cut off the industrial consumers of natural gas in order that the domestic consumers may have sufficient gas for house heating purposes when the supply is short.

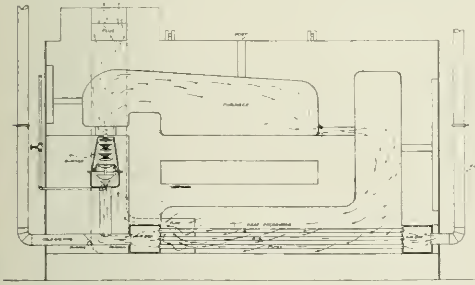


Fig. 1—Cross section of burner as used in forge shop.

This type of oil burning apparatus is of the gasification variety. It is safer and less expensive to operate than oil burners of either the mechanical or atomizing type. It is as easy to install as a gas burner and as simple in its operation as any gas heating appliance. Oil is consumed without the production of smoke or odorous vapors. Steam, high pressure, air or artificial pressure on oil are not required. Air, under a pressure of from one-half to two ounces, delivered by a small fan or blower, is adequate for all of the heat requirements of any metal, heat-treating, forging, or glass plant.

Fig. 1 is a vertical cross-section drawing of an installation in a forging furnace. Reference to the drawing will disclose the manner of installation of burner and the means of oil and air supply of it.

The forging furnace is 4 feet wide, 8 inches long, and 5 feet high. Arrangement is made for the exchange of heat between outgoing, hot flue gases and the fresh air incoming, to the burner. All of the heat imparted to the incoming air contributes very materially to efficiency of use of the fuel and makes it possible to attain remarkably high temperatures in the heating chamber.

This forging furnace has been in practically continuous operation for the past three weeks and at no time has the temperature of the flue gases at a point 6 inches above the furnace been in excess of 650 degrees F. Temperatures of from 2,600 to 2,800 degrees F. are readily obtained and maintained in the heating chamber. It is possible by means of thermostatic connections to maintain and control any desired temperature between 500 degrees F. and 2,800 degrees F.

The consumption of oil in heating up the forging furnace varies from 5 to 6 gallons per hour. The time required, depending upon the oil consumption, is from 1 to 1½ hours. When once the temperature of the furnace has been raised to the desired temperature of from 2,000 to 2,800 degrees F., the oil consumption, to maintain this temperature, varies from 2½ to 3 gallons per hour.

The A-G-S oil burning apparatus is manufactured and distributed by the Pittsburgh Saw & Manufacturing Co.

New Books on Roll Pass Design

Prof. Trinks Reviews Two Recent Books On This Interesting Subject — They Stand Out As the Foremost Books Yet Published On Roll Pass Design.

Review by W. TRINKS

THERE are no good books in the English language on the subject of roll pass design; the art is carried on by exchange of information and of experience between members of the trade. Continental engineers have been more liberal with their experience and have published their knowledge for the benefit of others. The books by Geuze, "le laminage du fer et delacier" and by Brovot "Das Kalibreiren der Walzen" are well known in the United States and have been extensively used. However, both of these publications are old.

For that reason two comparatively recent publications on the subject will be of interest to roll pass designers. One of these is by F. Dehez. The name is "Walzenkahlrierungen." It was published late in 1919 by Verlag Stahleisen in Dusseldorf, Germany. It contains 46 pages 12 by 15 inches. The other book "Walzen Kahbrieren" was written by W. Tafel and was published in 1921 by Ruhfus in Dortmund, Germany. It contains 228 pages 5 by 9 inches and eight folded plates.

Professor Trinks of the Carnegie Institute of Technology will give a course in "Roll Pass Design," at that school this winter. The course begins October 3, 1921, and runs to April 24, 1922. Classes will be held every Monday evening from 7:30 to 10:30. Those who wish to take the course should either pass entrance examinations in Algebra, Physics, Plane Geometry, and English on September 20 and 21, or if they wish to enter with advanced standing, present themselves in the evening of September 28, 29 or 30. Additional information can be obtained from the Institute of Technology.

The two publications are quite different in character and really supplement each other. Dehez's book is a collection of successful designs with but little text, while Tafel's book is an explanation of the underlying phenomena and an attempt to find both a reason for and a solution of each of the problems which confront the roll pass designer. Dehez spent his life in the mill and in the working out of successful roll pass designs. The drawings of the latter need but little comment and should be of assistance to any roll pass designer, regardless of whether he knows German or not. The designs cover rails of various sizes and rails used in different methods of rolling. They cover plain and complex angles finger-bars, rib-rails, moldings for safes, skylights and other purposes, rib-treads, mono-styles, single and double railroad ties. No designs are given for simple sections such as flats, rounds, squares or skelp, because as Dehez states, such designs have been published elsewhere, and because the designs are frequently subordinate to economic conditions and to conditions of mill operations. With most of the designs, tabulations and charts are given which indicate the reduction in the various component parts of the sections. It is somewhat strange that no designs of I beams have been given. Mr. Dehez died from a stroke while the book was being printed.

Mr. Tafel's book is very different. It is mostly text, and illustrations are only those which the word indicates, namely, means for illustrating text-matter. As the author states the book is an introduction into the theory and into an understanding of rolling and of roll pass designs. The book does not intend to show solutions of some one else's problems, but will help the reader to correctly solve his own problems. It does not give recipes, but aims to give an insight into the reasoning which is necessary for successful roll pass design.

The book takes up nomenclature, calculation of spreading, forward slippage, gripping, and defects in the stock due to improper roll design. It deals with wear of rolls, overfilling and underfilling, location of the passes in the roll, with side work and with many other features of roll pass design. It deals with error made in the design and with their consequences. It then enters into roll pass design, for flats and skelp, for hand and guide squares, hand rounds and guide rounds, every where giving reasons for each step and numerical examples. It takes up pass design for roughing rolls and enters into roll train resistance. Finally it goes into pass design for structural material and similar shapes, saying very little, however, on the subject of I beams.

Tafel who is professor of steel works design in Bresban knows the practice of rolling. He has rolled, and speaks from experience. Many a reader will not agree with all of Tafel's theoretical explanations, but the latter are well advanced over those of previously published books. Those who can struggle through a German text will be well repaid for the effort made in studying the book. One point, which is practically omitted in all other books, namely the design of guide and of guide boxes is treated by Tafel at quite some length. The book well deserves to be translated into English.

For the benefit of those who may wish to purchase either one of these books it should be mentioned that J. E. Steckert & Co., 151 West Twenty-fifth Street, New York City, carry a stock of almost all important German technical books. On account of the low value of the mark, the books are quite inexpensive.

250 YEARS OF BLAST FURNACE OPERATIONS AT WASSERALFINGEN

The iron works at Wasseralfingen, in Wurttemberg, which have now been in existence for 250 years were not the first iron works of Wurttemberg, which is not conspicuous among the iron-producing countries. But the name of von Faber du Faur, who was manager of these iron works a century ago, is well known, and his suggestion of utilizing the blast furnace gases for generating heat and power, made Wasseralfingen famous. The ore utilized in these districts is the oolitic iron ore (Bohnerz) of the Suabian Jura. The first Wurttemberg iron works mentioned, in 1365, are those of Konigstronn.

WITH THE EQUIPMENT MANUFACTURERS

IMPROVED CONTACTOR FOR D. C. MOTORS

A new and improved form of contactor, known as the bent frame type, for dc motor control, has just been developed by the General Electric Company. The ampere ratings of the new line include a size range of from 50 to 1,500 amperes, and the line also takes in contacators for both normally closed and normally open operation.

These contactors were especially designed to meet the three principal requirements of electric motor drive, namely, continuity of service, simplicity and durability. Continuity of service implies not only the fact that the contactor will work well for a long period of time, but that the wearing parts shall be so designed and constructed that their replacement is a matter of a few minutes, requiring no interruption of service. How the new contactors meet requirements is best seen from an explanation of their mechanical and electrical characteristics.

In the new line, particular attention has been paid to the construction of the parts directly concerned in breaking the circuit. Under severe service conditions contactors of former construction required frequent renewal of the tips and arc chutes because these parts were rapidly burned by the concentration of the arc at the tips.

In the new contactors, this concentration of the arc is prevented by: first, the use of large pear-shaped pole pieces, which give an increased force and distribution to the blowout flux; secondly, the arc chute has been increased in size, which increases its radiation, and restricted at the mouth, which forces the arc across the burning surfaces at such a high velocity that it does not burn them at any spot. Furthermore, the tips have been provided with arcing horns which protect both them, and the screws holding them to the contactor.

By these means the life of the tips and chutes has been greatly increased, and the rupturing capacity of the contactor as a unit has been made much greater than that of previous type. As to replacement expense, an actual life test showed that where it used to be necessary to renew contactor tips about once a week, and the chutes about once a month, both the tips and chutes of the new type contactor were in good condition after six weeks' operation.

The armature construction varies slightly with the different sizes. On the 40-ampere size it is a punched steel plate with a right angle piece bent out at the bottom. On the 80 to 600 ampere sizes it is bent steel U-shaped section to which is attached the arm carrying the moving contact, and on the 900 ampere and 1,500 ampere sizes, the section is of cast steel. The armature fits inside the frame, which is also a U-shaped piece of steel plate, the former being hung on a pin which fits in bushings. The armature and bracket pins both have a longer life in these contactors, due to the direction of the forces acting on them. This means that the contactors will operate satisfactorily for a longer period, with resultant reduced maintenance cost. Another improved feature is the operating coil, which slips on over the core, and is held by bronze washer fitting in a slot in one end of the core. The coils are somewhat longer in proportion to their diameter, which increases the radiation factor, increasing the allowable voltage range on which the contactors will operate. As to the shunts, they are flexible material, and are clamped directly to the contacts, a construction which reduces local heating for two reasons: one, because the number of joints through which the current has to pass are reduced to a minimum, and the other because they make good contact, being soft even on an uneven surface.

The normally closed contactors are similar to the standard normally open ones, with the addition of extra parts, and present the similar appearance. The frame and armature are inverted, and the contacts held closed by springs.

ARC WELDING SUPPLANTS RIVETS FOR STRUCTURAL WORK

That arc welding is continually finding new and important industrial applications is being demonstrated by numerous reports of successful welding. In a recent publication issued by the Westinghouse Electric & Manufacturing Co., entitled "Arc Welding Applications," many interesting and novel uses of arc welding are explained and illustrated.

One of the applications shown is the first structural steel building ever erected without the use of rivets. The electric arc was employed throughout the entire construction to unite the structural steel members. Inasmuch as the entire construction was tested and approved by the New York Bureau of Buildings, the arc welding process for this line of work has passed from the experimental stage to the practical commercial stage. The trusses are designed for a live weight of 40 pounds per square foot, each truss supporting a panel of 800 square feet. They were tested at a load of 120 pounds to the square foot, or a total load of 48 tons on the two trusses.

The main advantages of arc welding, for this work, are the elimination of the necessity for fabricating the steel parts and the saving of time in waiting for the girders to be fabricated. Another decided advantage of the arc welding method over that of rivetting is that it does away with the noise of rivetting and makes it possible to work day and night without causing any disturbance.

This unique example of the use of arc welding has aroused a great deal of interest in the building trades and industrial plants. Although no extended use of this principle has been made as yet, it is quite possible that great development may be made in the near future.

NEW BROWN COLD JUNCTION COMPENSATED PYROMETER

Patented December 28, 1920.

The Brown Instrument Company, Philadelphia, Pa., is placing on the market a new thermo-electric pyrometer, which is automatically compensated in the instrument for changes in cold junction temperatures and which includes means of setting the pointer of the instrument to zero in the usual manner.

This is an improvement on the method of cold junction compensation developed by Darling in England, in 1909, and an improvement on a few subsequent developments for automatic cold junction compensation brought out since that time. These former methods afforded no means of setting the instrument to zero. It is customary on all electrical instruments, including millivoltmeters and pyrometers, to supply a zero adjuster to enable the user to set the instrument to zero, provided the zero has shifted, due to jars in transportation or with continual service. The Brown method is the only one which embodies this most necessary feature.

NEWS OF THE PLANTS

The Seaboard Iron & Steel Company, 905 Lake Drive, Baltimore, Md., has awarded a building contract for the erection of a new plant on South Pica street, near West street. The works will comprise a number of buildings with main one-story structure for general iron and steel operations. It is proposed to commence erection at once, having the plant ready for service at an early date.

The Carnegie Steel Company, Pittsburgh, Pa., a branch of the United States Steel Corporation, has filed plans for the construction of a new two-story building at 1275 Reedsdale street, Pittsburgh, for general iron and steel production. The new works will cost about $50,000. Construction will be commenced immediately.

The Triangle Steel Products Company, Chicago, Ill., care of T. C. Casse, 163 Washington street, has plans nearing completion for the construction of a new plant at Michigan City, Ind., to comprise a one-story and basement structure, equipped for the manufacture of steel specialties. The plant will be 250 x 500 feet, and is estimated to cost approximately $75,000, including equipment.

The Kingsbridge Iron Works, Inc., 408 East Ninety-ninth Street, New York, N. Y., has acquired a portion of the former Morris Park race track, near Fowler avenue, as a site for the establishment of a new plant. An existing building on the tract will be remodeled and improved, and additional structures erected. Plans are being drawn and construction will be inaugurated at an early date. A large department of the new works will be devoted to ornamental iron manufacture.

The Riverside Bridge Works, Martins Ferry, Ohio, is planning for the immediate erection of a number of additions to its plant for increased production. The work will include an extension to the main fabricating works, forge shop and other plant structures, and will double, approximately, the present plant output. The work is expected to cost in excess of $60,000.

The Minnesota Steel Company, Duluth, Minn., a subsidiary of the United States Steel Corporation, has completed the purchase of water front property in the Morgan Park district, totaling about 330 acres of land. The site extends along the Minnesota side of the St. Louis river, between New Duluth and the company's present works. Tentative plans are under way for the construction of a number of additions to the plant, and it is said that a fund of about $5,000,000 has been set aside for this purpose.

The Columbus Forge & Iron Company, foot of West First avenue, Columbus, Ohio, has taken bids for the erection of an addition to its plant for increased production. The extension will be one-story, 70 x 200 feet, and 110 x 120 feet, and is estimated to cost close to $90,000, including machinery. It is proposed to commence erection at an early date.

The Lackawanna Steel Company, Buffalo, N. Y., is arranging to market a portion of the pig iron produced at its different blast furnaces, and the output in the future will be proportioned for the company's requirements at its steel mills and the regular merchant iron market. The company in normal times operates a total of 9 blast furnaces and 24 open-hearth furnaces, with 11 rolling mills at the main works. The plant uses about 2,250,000 tons of ore, 1,500,000 tons of coal and 650,000 tons of limestone per year. The pig iron to be sold will be handled direct through the company's branch offices.

The Builders' Iron & Steel Co., Garvey street, Everett, Mass., has awarded a building contract for the erection of a new one-story plant for general production, estimated to cost about $80,000. Ground for the works will be broken at once.

The plant of the Standard Process Steel Company, North Broad street, Phillipsburg, N. J., has been sold by the liquidating committee of the company to W. P. Barba, Thirteenth and Cherry streets, Philadelphia, Pa., and associates, for a consideration said to be about $50,000, with mortgage of $10,000. Mr. Barha was formerly a vice president of the Midvale Steel Corporation. The interests acquiring the plant will make a number of improvements in the works and install new machinery, as required, for the manufacture of steel products. It is proposed to inaugurate work at once and have the plant ready for service at an early date.

The Tomahawk Steel & Iron Works, Tomahawk, Wis., is completing plans for the construction of a new plant to replace its works recently destroyed by fire. The new building will be two and three-story, 100 x 180 feet, and estimated to cost about $80,000. W. P. Ireland is supervising engineer for the work. William Bauman is general manager.

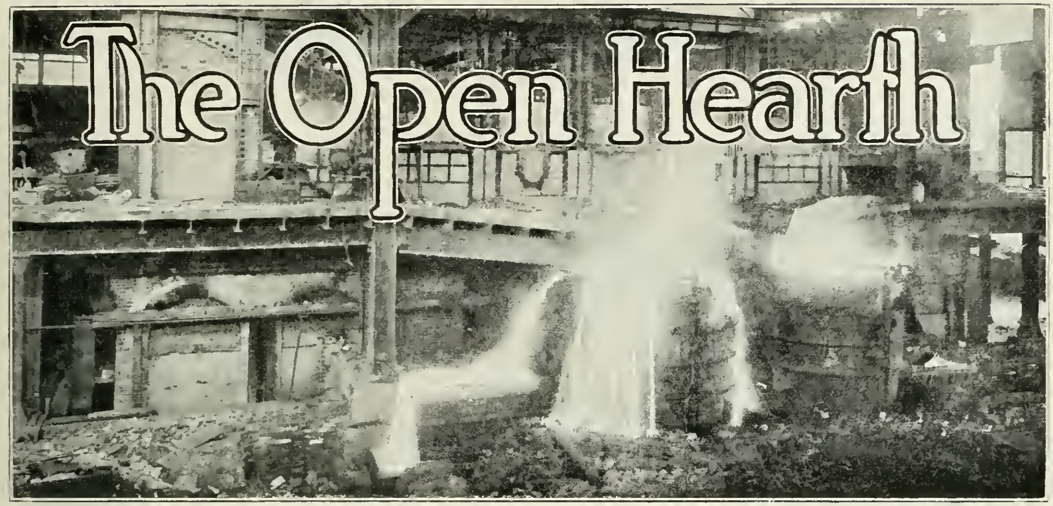
The Hancock Steel Company, Martinsburg, W. Va., has preliminary plans under way for the erection of its proposed new plant at Brocius, W. Va., near Hancock, Md. The works will comprise a main one-story mill, 130 x 200 feet, with a number of smaller buildings, and are estimated to cost in excess of $500,000, including machinery. Ernest McGeorge, 1900 Euclid avenue, Cleveland, Ohio, is architect. F. Vernon Aken is head of the company, which was organized several months ago.

The Illinois Steel Company, South Chicago, Ill., is completing plans for the erection of a new three-story building at its plant, 92 x 375 feet, estimated to cost about $350,000. L. C. Holmboe, 3426 East Eighty-ninth street, South Chicago, is architect and engineer.

The Sharon Steel Hoop Company, Sharon, Pa., has resumed production at four of the finishing mills at its plant, following a shutdown of several months. The works will give employment to about 500 operatives. It is planned to place other departments of the works in service at an early date.

The Wheeling Corrugating Company, 2547 Arthintgon street, Chicago, Ill., manufacturer of steel products, has completed plans for the erection of an addition to its local plant for increased production. The extension will be one-story, 80 x 125 feet, located on Arthington street, and estimated to cost about $40,000. Paul Gerhardt, 64 West Randolph street, Chicago, is architect.

The Open Hearth



E. W. Crellin, president of the Pittsburgh-Des Moines Company, has retired. W. H. Jackson has been elected president, O. E. Guibert and W. W. Hendrix, vice presidents, and George A. Smith, secretary and treasurer. Mr. Smith has removed from Des Moines to Pittsburgh and A. C. Pearsall has been made general manager of the Des Moines branch.

V V

Robert Wilson recently resigned as superintendent of the Fabricated Steel Products Company, Leetonia, Ohio, and is now connected with the Adams Manufacturing Company, East Palestine, Ohio.

V V

Lawrence Johnson, who for 19 years was factory engineer of the Collins Company, Collinsville, Conn., maker of edge tools, and now associated with Perin and Marshall, will leave for India next month, where he will assume the position of works manager at the Jamshedpur plant of the Agricultural Implements Company, Ltd., Bombay.

V V

Fred C. Harris, Duluth, general superintendent of the Zenith Furnace Company for the past 17 years, recently retired and has been succeeded by H. A. Brady, who has been assistant general superintendent. His first experience in making iron was at a forge in Schroon, Eessex County, N. Y., when he was 14 years old. Then he spent 10 years at the Crown Point magnetite iron mines in New York, where he also gained a knowledge of smelting and in making ferromanganese. At 35 Mr. Harris was employed at Edith furnace of the American Steel & Wire Co., then he went to Cleveland as general foreman of the Central Furnace Company. For the past 17 years he was general superintendent at Duluth.

V V

Thomas Chalmers, superintendent of the Tennessee Coal, Iron & Railroad Co.'s by-product plant, at Fairfield, Ala., who went to Colorado for his health several weeks ago, is reported to be much improved and expects shortly to return to Birmingham to again take up his duties. Mr. Chalmers directed the construction of the new battery of ovens at Fairfield.

V V

Isaac Harter, assistant to the president, Babcock & Wilcox Co., New York, manufacturers of boilers and stokers, was recently appointed general superintendent of the company.

B. D. Lockwood recently resigned as chief engineer of the Pressed Steel Car Company, Pittsburgh, and J. F. Streib, formerly assistant chief engineer, succeeds him.

V V

George D. McDougall, general superintendent of the Nova Scotia Steel & Coal Co., New Glasgow, N. S., has been appointed chief engineer of the British Empire Steel Corporation, and Archie McColl, secretary of the Nova Scotia company and assistant to the president for many years, will be general manager of the Nova Scotia Steel & Coal Co.

V V

C. L. Close, manager of the Safety, Sanitation and Welfare Bureau of the United States Steel Corporation, 71 Broadway, N. Y., and G. K. Leet, secretary to Chairman E. H. Gary, left recently for a fishing trip in Northern Canada.

V V

Charles J. Hunter, vice president and treasurer of the Wheeling Steel & Iron Co., Wheeling, W. Va., has been elected president of the company, succeeding John Duncan, who resigned recently, to become actively associated with the Illinois Company, St. Louis, owner of coal, coke, iron and railroad properties in Southern Illinois. Mr. Hunter, who is now 50 years of age, has been associated with the Wheeling Steel & Iron Co. since he was 19 years of age. Upon graduation from high school he entered the service of the Benwood Iron Works. Alonzo Loring at that time was president of the company. Mr. Hunter continued with the company following the merger of the Benwood Iron Works, Wheeling Iron & Nail Co. and Belmont Nail Co. in 1892. He advanced from the position of office boy to that of invoice clerk, then to paymaster, bookkeeper and purchasing agent, which position he held for a period of 13 years. He then became secretary and treasurer, and finally vice president. Mr. Hunter is the fourth president of the Wheeling Steel & Iron Co. C. R. Hubbard was its first president, and upon his resignation I. M. Scott was chosen to fill the vacancy. A year ago following the merger of the Wheeling Steel & Iron Co., Whitaker-Glessner Company and the La Belle Iron Company as the Wheeling Steel Corporation, Mr. Scott was elected president of the corporation, and Mr. Duncan succeeded him as president of the Wheeling Steel & Iron Co

The Open Hearth

Charles V. McIntire recently resigned his position as chief engineer of the International Coal Products Corporation, to become associated with A. Stephen Knowles, 66 Broadway, New York. Mr. McIntire, prior to his connection with the International Coal Products Company, was for five years actively engaged in the design and construction of by-product coke ovens. He served with the Koppers Company for six years as electrical engineer and later assistant chief engineer, and for a period of five years was chief engineer of the Wilputte Coke Oven Corporation, New York.

V V

Homer A. Pardee, general manager of the Halcomb plant of the Crucible Steel Company of America, Syracuse, N. Y., has been appointed manager of the Park works of the company at Pittsburgh, succeeding George I. Page, who resigned recently. James A. Scott, assistant manager of the Park works, has also resigned.

V V

Norman W. Warren was appointed general manager of the Dominion Bridge Company recently, with headquarters at Montreal. He was born at Kensington, Conn., and studied engineering at Yale. In 1911 he became assistant chief draftsman for the National Bridge Company and was appointed the following year chief draftsman. After the National Bridge was absorbed by the Dominion Bridge Company, Mr. Warren was appointed acting manager for Western Canada, and in 1916 became Western manager, which position he has held since that time. He has been chairman of the Prairie provinces branch of the Canadian Manufacturers' Association.

V V

John Duncan, who recently resigned as president of the Wheeling Steel & Iron Co., Wheeling, W. Va., to engage in the operation of coal, coke, iron ore and railroad properties in Illinois, also resigned as vice president of the Wheeling Steel Products Company, Wheeling, the selling organization of the Wheeling Steel Corporation and its subsidiaries, the Wheeling Steel & Iron Co., La Belle Iron Works, Steubenville, O., and the Whitaker-Glessner Company, Portsmouth, Ohio.

Dr. Richard Moldenke was last week a guest at luncheon of the Worcester, Mass., members of the New England Foundrymen's Association, at the rooms of the Worcester Metal Trades Association, that city. H. P. Blumenauer, general manager Arcade Malleable Iron Company, presided. Dr. Moldenke spoke on foundry costs and on his observations of conditions in Europe, gathered during a trip from which he recently returned.

V V

J. T. Kane, who for many years was general superintendent in charge of shipping at the Trumbull Steel Company, Warren, O., now is warehouse superintendent for the Sheet Metal Manufacturing Company, Youngstown, O.

V V

J. W. Hocking, secretary Wheeling Steel Corporation, Wheeling, W. Va., who resigned recently, was secretary of the Whitaker-Glessner Company prior to the combination of that company with the Wheeling Steel & Iron Co. and LaBelle Iron Works, into the Wheeling Steel Corporation.

V V

William C. Reilly, general superintendent of the Youngstown Sheet & Tube Co., Youngstown, Ohio, has been selected by the provincial Government of Nova Scotia as its representative in arbitration proceedings with the Dominion Steel Company, involving settlement for steel used during the war aggregating $9,000,000. During the war, the Dominion Steel Company erected a large plate mill at the request of the government and entered into a contract for plates for military purposes. When the armistice was signed the contract was half completed, and the government, having no further use for the plates, cancelled its contract. In the interim efforts have been made between the company and the Government of Nova Scotia to agree upon an amicable settlement, but without avail. Mr. Reilly has gone to Sydney, N. S., where the plate mill is located, to meet with representatives of the company.

V V

Allen G. Goldsmith, Milwaukee, who, during the period of 1911-1917 was associated with the American Rolling Mill Company, Middletown, Ohio, in various capacities up to department manager, has been appointed to take charge of the Western European division of the Bureau of Foreign and Domestic Commerce.

Some Pointers on By-Product Coke Oven Operations

STEEL CORPORATION TO BUILD COKE OVENS

It is reported that the United States Steel Corporation are contemplating the building of a large number of by-product coke ovens at New Castle, Pa., the ovens to be used in connection with their various plants located in this vicinity.

It is the intention of that company to build a thirty-mile railroad, connecting up the new by-product plant with the main line of the Bessemer and Lake Erie Railroad at Kaylor, Pa. The survey for the railroad has been completed.

TO STUDY BY-PRODUCT COKE OVENS OF THE SOUTH

G. St. J. Perrott, associate physical chemist of the United States Bureau of Mines Experiment Station, Pittsburgh, Pa., is to be sent to Birmingham, Ala., to study the physical properties of coke in relation to its production and use in the blast furnace. Blast-furnace operators declare that there is a decided lack of knowledge regarding the physical and chemical properties of coke in producing iron ore. In the stress of wartime they found it necessary to use almost anything in the way of coke material that was offered, and, it is said, they found they could use materials that before seemed impossible. It is believed, therefore, that the investigation proposed offers a very fertile field for the obtaining of very interesting information. Conditions are very favorable for the conducting of these investigations at the Tuscaloosa Experiment Station of the Bureau of Mines, where there are quite a number of small blast furnace plants and by-product plants, many of which are ready to carry on investigating work.

STEEL MAKERS AS COKE SELLERS

Not only are the steel companies making the market in pig iron, but they threaten to become the dominating influence in the coke market, at least temporarily. This possibility is suggested by the fact that a Youngstown district steel company, which recently blew in a blast furnace, contracted for its fuel requirements from a nearby steel company having by-product ovens. This company formerly bought beehive coke for its furnaces, as it probably would be doing now if business were normal and the steel companies having by-product plants were using all the coke they produce. The lowest price quoted by the Connellsville operators against the inquiry, which was for about 12,000 tons a month over the remainder of the year, was $3 per net ton at ovens. The buyer was able to get by-product coke at $2.50 per net ton, Connellsville base, a saving of 50 cents per ton, or $6,000 per month. It is necessary to keep by-product plants in partial operation at all times to prevent heavy repair charges, and there are also in some cases gas contracts, and the steel companies in the Youngstown district, and probably in all other districts, which have by-product plants, are producing more coke than they need, since they have only one blast furnace in five on an average making iron.

It was the marketing of surplus pig iron by the steel companies that established market prices in steel-making grades of iron, and now that the steel companies have surplus by-product coke for sale and the capacity for commercial production, the beehive coke producers have a condition to meet that may have to be reckoned with for a considerable time. The fact that many merchant blast furnaces stopped making iron did not prevent prices from slipping, and likewise the curtailment of beehive coke making has its limitations as a price corrective, seeing that the steel companies must keep their by-product plants going and will take low prices for coke to prevent burdensome accumulations.—Iron Age.

BY-PRODUCT COKE OVEN COMPANY FORMED

The Belgian-American Coke Ovens Corporation, New York, has been formed with a capital of $10,000,000 to construct and install Piette by-product coke ovens and carbonization equipment for fuel saving. Olivier Piette, of Belgium, holds the patent rights to the coke ovens and appliances, and will be on the board of directors of the new organization, which is headed by Thomas F. Ryan and F. S. Landstreet, both of New York. The latter has been elected president of the company and offices have been established at 25 Broad street. The American corporation will have the assistance of technical experts from Belgium. The European organization is known as the Franco-Belgian Coke Ovens Corporation.

AGREE TO CUT FREIGHT RATES ON STEEL AND IRON

The transcontinental rail carriers have agreed on reduced rates for iron and steel products originating at eastern points, and only need the concurrence of the New England lines to make the reductions effective, G. W. Luce, general freight agent of the Southern Pacific Company, announced.

It is proposed to make the reductions effective October 3. An endeavor will be made to have the Interstate Commerce Commission suspend its long and short haul ruling which prevents the lines from making long haul rate concessions.

MEETING OF THE A. I. M. E. AT WILKES-BARRE

The Wilkes-Barre meeting of the American Institute of Mining and Metallurgical Engineers should prove a very interesting affair to all who attend. The final program has not yet been announced, but among the papers to be presented are the following:

"Petroliferous Rocks in the Serra da Baliza." By E. P. de Oliveira.

"Underground Mine Development, Its Definition and Valuation." By J. B. Dilworth.

"Geology of the Namma Coal Field, Burma." By Edel Moldenke.

"Anthracoal: A New Domestic and Metallurgical Fuel." By Donald Markle.

"Mine Fires Extinguished by Sealing." By Douglas Bunting.

"Ashley Planes for Handling Freight Traffic." By C. H. Stein.

"General Geology of Catorce Mining District, Mexico.' By C. L. Baker.

"Mechanical Mining of Anthracite Coal." By H. D. Kynor.

"Power Installation at Coverdale Mine, Pittsburgh Terminal R. R." By Charles M. Means.

"Automatic Sub-stations as Applied to Coal Mining." By R. J. Wensley.

"Determination of Electrical Equipment for a Mine Hoist." By Graham Bright.

"Slush Problem in Anthracite Preparation." By John Griffen.

"Lynch Plant of the United States Coal & Coke Co." By H. N. Eavenson

TRADE NOTES

The W. A. Jones Foundry & Machine Co. announce the appointment of Mr. Robt. B. Moir as manager of their New York branch. He will assume his new duties immediately, making headquarters at the present sales office and transmission warehouse of this company, 20 Murray street. He has been actively connected with the home office and factory for a number of years and is exceptionally well qualified to assist in power transmission and general engineering problems. This change will enable the Jones Company to coöperate with their many friends in the New York district even better than in the past.

Mr. E. S. Crosby, sales and advertising manager for the United States and Cuban Allied Works Engineering Corporation has resigned to become manager of the Eastern District of the Celite Products Company, producers of the well known Sil-O-Cel insulating material, and Filter-Cel the ideal filtering medium. Previous to his service in France with the army, he was assistant sales manager for the De Laval Steam Turbine Company of Trenton, N. J. He will make his headquarters at 11 Broadway, New York.

The agency arrangement for the sale of sheet steel heretofore existing between Thos. Firth & Sons, Ltd. of Sheffield and Wheelock Lovejoy & Co. of New York and Cambridge, has been terminated, and Thos. Firth & Sons have appointed as their general sales manager for the United States, Mr. Horace G. Hides of Hartford, Conn., who has for the past twenty years represented Wm. Jessop & Sons.

The stock of Firth Sheffield Sheets will be carried in the warehouse of the Firth-Sterling Steel Company, 312 Hudson Street, New York City, an associate company.

The Lumen Bearing Company of Buffalo, N. Y., and Youngstown, Ohio, manufacturers of the well-known line of machine bronze, brass and bronze, castings and bearings, solders and babbitts, have, owing to the increase in their activities, found it necessary to locate in Chicago a branch office that will supply and handle all business of the company west of and including Michigan with the exception of the city of Detroit, and west of a line from Toledo, to Columbus to Cincinnati; Kentucky, Tennessee and Georgia. Mr. H. S. Huncke is the western sales manager, with Mr. Henry Waters as associate salesman. The office is located at 15 North Jefferson street, Chicago.

Advices have been received to the effect the Cincinnati office of the Cutler-Hammer Mfg. Co., Milwaukee, has been moved from the Dwynne building to the Dixie Terminal building. A. R. Maujer, formerly of the sales engineering force of the Pittsburgh office, is now in charge in the Cincinnati district.

Discontinuance of its Boston office recently was announced by the Eastern Steel Company, but it is understood Harry O. Russ will continue to represent the company in the New England district with headquarters in the New York office, 50 East Forty-second street.

Advices have been received to the effect that the general offices of th La Belle Iron Works are now located in the Wheeling Steel Corporation building, Wheeling, W. Va., possession of the new quarters having taken effect August 15.

A merger has been effected between the Stowell Company, South Milwaukee, and the Pelton Steel Company, Milwaukee, whereby the Stowell Company secures the business of the Pelton Company. It is the intention to continue operating the Pelton plant under the old name and to maintain the same organization. The Stowell Company has had steel casting facilities for some time, but now counts on added capacity and scope of quality.

TRADE PUBLICATIONS

Simon-Carves, Ltd., Manchester, England, have issued a very well illustrated pamphlet covering a coal washing, handling and crushing plant.

"Superheated Steam in Small Locomotives," is the title of a most interesting booklet issued by The Superheater Company. It covers this subject completely.

The new line of electric furnaces which has recently been added to the products of the Westinghouse Electric & Mfg. Co., is very ably described and illustrated in catalog, 9-C, which is being distributed. This type of furnace includes the multiple unit designed for use with heats of 1800 to 2000 degrees F. The small Hevi-duty furnaces of the multiple crucible type may be operated continuously at 2000 degrees F. Hevi-duty industrial furnaces with applications for annealing, hardening, drawing and enameling, are described in minute detail in this publication. A discussion of the characteristics of these furnaces is also given.

Application of Oil Circuit Breakers is the title of a new publication issued by the Westinghouse Electric & Mfg. Co., East Pittsburgh, known as Special Publication 1643. This includes a complete discussion of the application of circuit breakers, together with an outline of the characteristics of several types of Westinghouse oil circuit breakers.

The Wayne Oil Tank & Pump Co., of Ft. Wayne, Ind., have recently issued a series of bulletins on the various problems of burning fuel oil and the necessary equipment therefor. Great pains have apparently been taken not only to describe and illustrate the equipment manufactured by this company, but to give a great deal of information applicable to the general problem of burning oil, and the bulletins should prove of exceptional interest to engineers and plant owners who contemplate using oil as fuel. The bulletins are bound in an artistic leatherette cover, size 8½ x 10½, which is both handsome and serviceable.

A new catalog, No. S21, issued by the Direct Separator Company, Inc., Syracuse, N. Y., is just off the press. As an introduction to descriptions and illustrations of the apparatus manufactured by this company, a short historical sketch is given, followed by a presentation of the problems "Water in Steam," and "Separating Water from Steam." In addition to descriptions and illustrations of the various types of separators, the catalog contains tables of dimensions for both oil and steam separators, and reports of tests proving their efficiency. Size 6 x 9.

The Atlas Valve Company of Newark, N. J., have recently issued their bulletins Nos. 1, 1-A, 2, 4 and 5 bound in a loose leaf folder, size 6 x 9. These bulletins consider, respectively, the reducing valves, Ideal pump governors, Atlas pump governors and float valves, bronze unions and swing joint pipe fittings, and Victor damper regulators manufactured by the company. The bulletins contain completely illustrated descriptions of the equipment together with price lists.

COMING MEETINGS

September 6-10—American Chemical Society, the Society of Chemical Industry and the American section of the latter organization will hold a joint meeting in New York. Charles L. Parsons, P. O. Box 1505, Washington, is secretary of the first mentioned society.

September 12 — National Exposition of Chemical Industries, in the Eighth Coast Artillery armory, New York.

September 12-17—American Institute of Mining and Metallurgical Engineers, will hold its fall meeting at Wilkes-Barre, Pa. Frederick F. Sharpless, 29 West Thirty-ninth street, New York, is secretary.

September 19-24—American Society for Steel Treating. Annual convention and exhibition at the Manufacturers building, state fair grounds, Indianapolis. W. H. Eisenman, 4600 Prospect avenue, Cleveland, is secretary.

September 29-October 1—American Electrochemical society, fall meeting, Lake Placid, N. Y. Joseph W. Richards, Lehigh university, S. Bethlehem, Pa., is secretary.

October -7—Society of Industrial Engineers will hold fall meeting at Springfield, Mass.

October 10-13—National Association of Purchasing Agents will hold its annual convention at the Claypool hotel, Indianapolis. L. F. Boffey, 19 Park place, New York, is secretary.

October 17-22 — American Mining Congress, will hold its twenty-fourth annual convention in the Coliseum, Chicago. Also national exposition of mines and mining equipment.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., OCTOBER, 1921 No. 10

New Blast Furnace of the Crane Iron Works Modernizes Plant at Catasauqua, Pa.

The First of a Series of Articles Describing Several Eastern Blast Furnace Plants, Which Were Pioneers in the Pig Iron Industry, and Which Have Recently Been Rebuilt to Conform with Modern Practice.

By RICHARD PETERS, Jr.,
Manager of Sales, Pulaski Iron Co.

TOWARD the close of our Civil War, John Percy of the Royal School of Mines of London gave to the iron making world his monumental work on the metallurgy of iron and steel, which for more than a generation was the leading authority on the subject which he presented. In the author's commentaries on the iron making establishments in countries other than his own, he dwells at length on the subject of the anthracite furnaces in the United States, concluding his remarks with the statement that "the principal manufacture must always cling to the Lehigh and Schuylkill and Lower Susquehanna valleys in Pennsylvania, where the ore is abundant, the coal near at hand, the flux on the spot, where the whole land is a garden and therefore food cheap and labor plentiful and the great sea ports not far off."

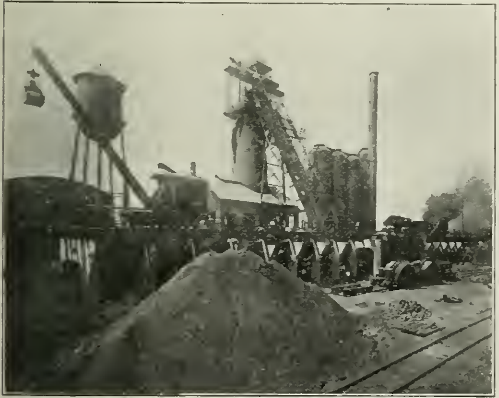


Fig. 1—General view showing the furnace, skip bridge, trestle, etc.

To a certain degree this prophecy of some 60 years ago has been fulfilled, although the changes brought forth by time and new methods have modified, to some extent, the broad assertions the author made in his work. Of the districts mentioned by Percy, the Lehigh valley has more nearly survived its promise, and while the anthracite coal used originally as fuel has been almost entirely replaced by coke from the western part of the state, and the local brown ores have given way to the Lake Superior hematites, yet the magnetites of New Jersey still remain an important part of the burden of the furnaces in the Lehigh district.

The successful use of anthracite coal as fuel for iron smelting measured the start of the pre-eminent position which this country enjoys in the manufacture of pig iron. It is therefore of more than passing interest to take cognizance of the recent completion of a modern blast furnace at Catasauqua, Pa., on the site of the pioneer plant which first produced pig iron as a commercial success with the above mentioned fuel. By the rebuilding of the number two furnace at its Crane Iron Works division, the Empire Steel & Iron Co. has accomplished a noteworthy addition to the present trend of reconstruction of American iron makers.

In order to more clearly comprehend the significance of the work, it is of interest to look backward over the history of the central unit of the Empire Company. In the period between 1825 and 1840, the iron masters of the eastern section of Pennsylvania made many attempts to smelt iron by using anthracite coal as fuel, but with the exception of a three months' campaign at Pottsville in 1839, the results were unsuccessful from a commercial standpoint.

The Lehigh Coal & Navigation Co. was anxious to have iron works established on their waterway and thereby use their fuel. Its board of directors therefore passed a resolution early in 1839, offering to give in fee simple all the water power of any of their dams between Allentown and Parryville, excepting that necessary for navigation purposes, to any company which would expend $30,000 in building iron works to smelt ores with anthracite coal as fuel.

The Lehigh Crane Iron Company, organized on the sixteenth day of May, 1839, signified its intention of accepting the proposition of the navigation company, and sent its representative, Erskine Hazard, to Wales to engage David Thomas, a practical furnaceman, to come to America to supervise the erection of a plant. Thomas had demonstrated the successful operation of Neilson's hot blast to anthracite iron smelting at Ynyscedwin Iron Works in his native country. Upon his arrival in this country he immediately repaired to the site selected by his employers, a few miles from Allentown, and commenced the erection of the first furnace. Construction work was attended by difficulties unknown to our present engineers, as in those early days there were no railroads in the Lehigh valley, and there were but few foundries or machine shops capable of making castings of any size. A large part of the blowing apparatus was brought over from England, and even some of this had to be remade in this country, owing to the fact that a portion of it was too large to be taken over in the vessel chartered for the purpose.

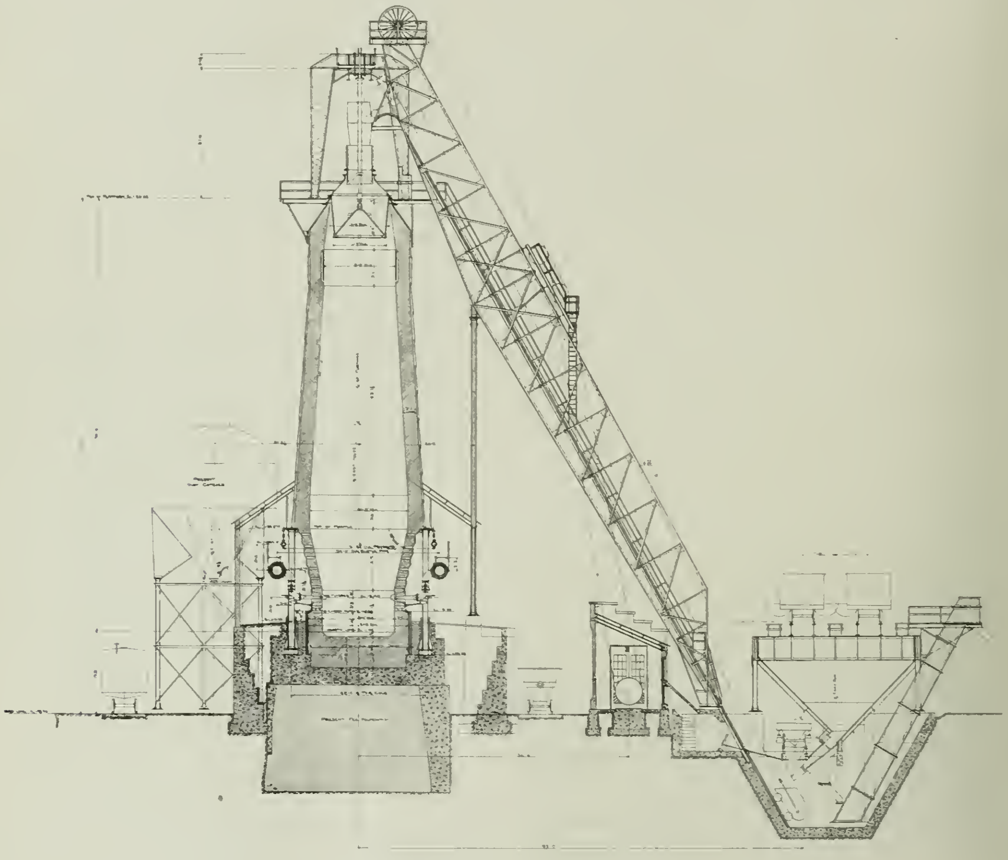


Fig. 2—Cross section of the furnace.

The original furnace was constructed of stone of the usual type of the period, 30 feet square at the base and 45 feet in height with a 10-foot chimney surmounting the furnace head. The bosh was 12 feet in diameter, while the hearth tapered from 5 feet 6 inches to 4½ feet. The hot blast oven was built on the ground and was arranged for coal firing, as no attempt was made in those days to bring gases down from the open top of the furnace.

The blowing apparatus consisted of two vertical iron cylinders worked by a pair of enormous wooden walking beams, bound with iron straps, which were driven by gears meshing into segments on the periphery of a breast water wheel 12 feet in diameter and 24 feet in length.

After numerous delays, the furnace was lighted on July 3, 1840, and the following day made its first cast of some four tons of iron. The enterprise being a success, the company erected a second furnace in 1843, using similar lines, but improving the arrangement of the hot blast by placing it near the furnace head. A third unit was built in 1846, giving a total weekly capacity of 420 tons to the works.

Until the year 1855 ushered in the advent of the opening of the Lehigh Valley railroad, all the raw materials for the plant were brought in by canal boats or by teams, and the countryside must have swarmed with wagons draying in the local brown ores from the neighboring counties.

In 1880, the No. 3 furnace having fallen down, it was determined to dismantle the original three stacks, leaving, however, Nos. 4, 5 and 6, which were built in 1849, 1850 and 1868, respectively. Two new furnaces, designed as Nos. 1 and 2, were built in 1880 and 1885, and at this time Whitwell stoves were installed, these being built under the personal supervision of Thomas Whitwell, and were the first of this type erected in Eastern Pennsylvania. The furnaces were not of the modern type of shells resting on columns, but consisted of stone work supporting the boshes, with iron extensions giving them the appearance of old fashioned railway water tanks.

The Crane Works were described by an early writer as a "noble pile," and old illustrations of the plant are hard to recognize as those of a smelting works, although they presented a picturesque aspect.

In the early 60's the furnaces at Catasauqua probably constituted the largest single plant in the United States, and furthermore, greater production per furnace than was reached elsewhere was accomplished by the bold steps taken by Thomas in blowing the stacks with higher blast pressure than had ever been previously attempted. An early writer, in commenting on Thomas' efforts, remarks: "The consumate skill and long experience of the manager must no doubt avoid or redress the ordinary troubles of the process, but the immense production can be accounted for only by the enormous consumption of oxygen. It is a satisfactory evidence of the constancy and reliability of the chemical and mechanical laws at our command for making iron that the introducer and oldest purchaser of anthracite iron in America has not been superseded, but is able still to lead off the greatly enhanced production with high figures. It is evidently no game of chance, but a trial of practical wisdom based on experience and insured by the improvement of all the means at the disposal of man."

In the past 30 years the work of rebuilding and dismantling contracted the plant to but two furnaces known as Nos. 1 and 2, and during this period much of the original plot was restored to its former condition.

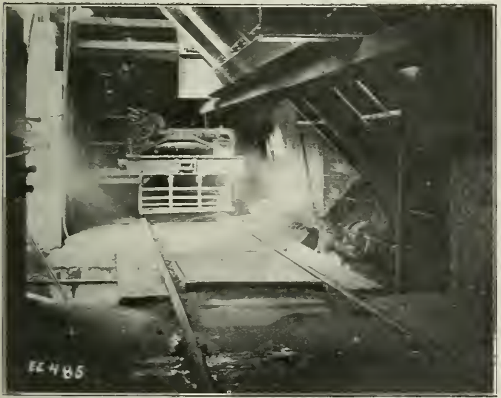


Fig. 3—Shows the scale car underneath the storage bins with the skip pit and coke bin discharge chutes in the foreground.

It may well be understood, therefore, that when the Empire Company decided to build a modern furnace on the site of a much rebuilt plant, that their engineers were confronted with difficulties widely in contrast to that of laying out work on virgin ground. Many of the existing appurtenances were to be retained for economical reasons, and it is to be borne in mind that the expansion of the plant was limited on one side by the Lehigh canal and on the other by the main street of the town of Catasauqua, while the ground between these boundaries is of limited area. This space was ample for even the six old stacks, for in the early days the necessary raw materials were not of great proportion, and the stock trestles were arranged between the furnaces as well as being adjacent to the canal.

Great credit is therefore due to the engineers and contractors, Arthur G. McKee & Co., of Cleveland, Ohio, who furnished designs and materials and supervised the erection under a fixed contract. In this work they followed the ideas and suggestions ably advanced by the officers of the Empire Steel & Iron Co., Messrs. Leonard Peckitt, president; James A. Stillman, secretary, and M. O. Knauss superintendent.

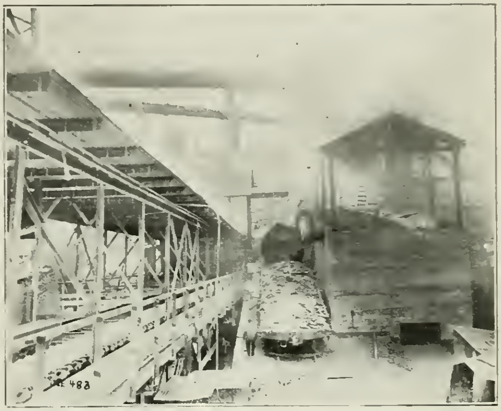


Fig. 4—shows the 75-ton mixer type hot metal ladle receiving iron from the furnace. The pig casting machine is shown at the left.

The improvement program involved the entire reconstruction of the furnace stack, the addition of a skip bridge, top structure and McKee revolving stack distributor, stock trestle and bins, hoist engine, scale car, pig casting machine and ladle cars, one new stove, new boilers, pumps, water tower and other auxiliary equipment.

The old stack was completely demolished and the foundation enlarged for the new work The new furnace has a height of 90 feet, hearth and bosh diameters of 15 feet and 20 feet 5 inches, respectively, and a 78-degree bosh. The shell is ½-inch plate with ¾-inch bottom ring, ⅝-inch top ring and ¾-inch top cone. The hearth jacket is 1¼-inch plate 9 feet high, cast iron hearth cooling plates 4 inches thick with cooling pipes being placed inside the hearth jacket. The tuyere breast is 4 feet 9 inches high of 1-inch plate. Eight rows of copper cooling plates are used in the hearth and tuyere breast. The new lining involves a total of 332,000 brick (9-inch equivalents), giving a furnace volume of 19,310 cubic feet. Cast iron wearing plates 6 feet in height are suspended from the top cone for protecting the brick work at the stock line. The large bell is 11 feet 3 inches in diameter, the small bell 5 feet 6 inches. The McKee revolving stock distributor is electrically driven and controlled, its operation being interlocked with the hoist engine so that the revolving and charging cycle is entirely automatic. The furnace top is equipped with a 25-ton trolley hoist for dismantling the furnace for repairs, and for raising material from the ground to the furnace platform.

The skip bridge is double tracked, of the through truss type, supported by a shear leg, independently of the furnace stack. The bridge has a steel plate deck and a stairway from the ground to the top platform. The skip cars have a capacity of 100 cubic feet of material each. A new steam hoist engine was installed, having 12x14-inch cylinders and a double grooved drum 66 inches in diameter The hoist engine house is placed directly under the skip bridge—as will be seen in the photographs, the ropes being led through the bridge by guide sheaves.

The stock bin structure is of steel and reinforced concrete, comprising a double tracked coke bin and 14 single tracked ore bins. The coke bin is of all steel construction with a capacity of 19,500 cu. ft. Two gravity chutes discharge the coke, over cascade screens, directly into the skip cars. The coke bin gates are controlled by the hoist engine operator and are in view from his post. The 14 ore bins are of steel, suspended from a concrete structure, each bin holding 2,130 cubic feet, giving a total bin capacity of about 1,879 tons of ore. The ore bins discharge into an electrically driven scale car of 80 cu. ft. capacity, the bin gates being continuous so that the entire contents of each bin can be discharged.

A single strand pig casting machine was installed in a structure of sufficient size to house a second strand when required. A 75-ton mixer type hot metal ladle car receives the metal from the furnace runners and delivers to the pig machine. The ladle car in receiving and pouring positions is shown in the photographs.

The boiler equipment of this furnace formerly consisted of approximately 3,480 hp of water tube boilers. This was augmented by the addition of two new 505-hp Stirling boilers which are equipped with Kling-Weidlein aspirating type burners for blast furnace gas. Other additions to the power equipment consist of two steam turbine driven pumps, each with a capacity of 2,500,000 gallons per day. A water tower giving storage for 80,000 gallons was also installed.

The increased size of the rebuilt furnace made necessary additional stove heating surface, and this was accomplished by adding one 20x100-foot McKee side combustion stove to augment the three Cowper stoves of smaller dimensions built in 1909. This work also included new air and gas mains and their connections.

The new stack is designed to produce foundry, forge and basic iron from a mixture of about 65 per cent New Jersey magnetite ore from the mines of the Empire Steel & Iron Co., and 35 per cent non-Bessemer Lake Superior Mesabi ore. Local stone is used, with Connellsville coke as fuel.

The rebuilding program at Catasauqua has brought to a culmination many years of changes and additions, which at best may be described as temporary and leading up to the present completely modern type of furnace. A number of other eastern iron manufacturers have also made notable improvements at their plants, namely the Wharton Steel Company, Wharton, N. J.; the Robesonia Iron Company, Ltd., Robesonia, Pa.; the Thomas Iron Company, Hokendauqua, Pa., and the Eastern Steel Company, Pottstown, Pa. The improvements made at the two plants first mentioned have been the subject of previous articles, and a complete description of the other plants will appear in the near future.

Recent Improvements in the Manufacture of Welded Pipe

While There Have Been Many Improvements in Appliances for Butt-Welding Pipe Since the Introduction of This Process, the Method of Finishing Has Not Been Materially Changed for Some Time.

By F. N. SPELLER, Member A. S. M. E.,
Metallurgist National Tube Company.

WHILE there have been many improvements in appliances for buttwelding pipe since the introduction of this process, the method of finishing has not been materially changed for some time. The process described in this paper involves welding the pipe larger in size than was formerly necessary, then after one rounding up pass the temperature of the pipe is reduced to a little above the annealing point (about 1,800° F.), after which the diameter is further reduced by passing through several rolls to the finished size. The straightening and cooling operations are then carried out as heretofore.

The object of these additional operations is primarily to remove the welding scale from the pipe, especially from the inside, so as to lessen the tendency for pitting and facilitate galvanizing or the application of other coatings. Incidentally this additional work done on the steel tends to improve the material and the weld.

Introductory.

The making of steam, gas and water pipe of wrought iron by the buttweld process has been carried on for nearly 100 years with many important changes to facilitate handling of the skelp, rapidity of welding and economy of operation. The process to be described has to do with the removing of welding-scale for the purpose of improving the finish and quality of the product. Before going into details it may be well to outline the more important steps in the development of this industry, chronologically considered.

Historical Development*.

The first attempt to make welded pipe by butting the edges of the hot plate together and forging, instead of first lapping them one over the other, was carried out in England by James Russell in 1824. This was improved in 1825 by Cornelius Whitehouse, whose process of drawing the skelp through a pair of bell-shaped dies forms the basis of the present buttweld process. The Whitehouse patent was assigned to James Russell and was used by him and other manufacturers after the patent expired.

In the United States the first furnace for the manufacture of buttweld pipe was built between 1830 and 1834 by the firm of Morris, Tasker & Morris, Philadelphia, Pa. At the present time there are 55 buttweld furnaces in this country with a capacity of approximately 1,000,000 tons per annum.

The earlier methods were, by contrast with later means, naturally cumbersome and slow. The first important improvement consisted of a fixed slotted die substituted for the original two-part die. Through this slot a pair of toothed jaw tongs was introduced, which grasped the heated skelp. By means of a draw bench chain the tongs and strip of skelp were drawn through the die and the flat skelp folded into tubular form with the edges butted against each other. This idea with modification is still used in forming the skelp for lapweld pipe.

On March 25, 1875, a patent was granted to George Matheson of McKeesport, Pa., for a device consisting of a fixed bell-holder slotted at the top, and a funnel-shaped bell which could be easily inserted and removed from this holder. Prior to this time all pipe was made from a strip of iron which was heated once, drawn through a die and then reheated to a welding heat and then drawn through a pair of funnel-jawed welding tongs. Welded to one end of the strip of skelp was a piece of round iron bar (the tag) with a knob on the end that engaged to a buggy which the operator also engaged to a draw bench chain. The funnel-shaped die of Matheson combined the two operations of bending the skelp and welding, materially decreasing the cost and increasing the rate of production. About 1895 a variety of pipe drawing tools and tongs came into use. The tongs were so designed as to pass through the funnel-shaped welding bell and grasp the pointed and upturned end of the skelp in the welding furnace and then engage to the chain of the draw bench. This greatly increased production and tended toward more uniform work.

Heretofore the plates with tags attached had been charged from the same end of the furnace from which they were drawn when heated, the welder and the men charging the cold skelp had to work in the same space and were therefore crowded and hampered in their movements. The introduction of practical improvements in drawing appliances paved the way for the next notable development by which the skelp was charged from the back end of the furnace through a low horizontal slot extending the full width of the furnace. By this means the furnace was kept full of skelp at all times when regularly operated, a cold piece being charged as a hot one was drawn and all parts of each piece of skelp are in the furnace the same length of time, whereas before the end first charged was the last drawn out. This system was patented by Mr. Peter Patterson of McKeesport, Pa., April 20, 1897. Since then electrically driven mechanical charging machines have been introduced, doing away with considerable laborious work.

The length of pipe welded in one piece had been increased from a few feet to 20 feet. The next step was to build a 40-ft. or double length furnace, the first of which was put into operation at McKeesport, Pa., in 1901, and was completely successful on pipe up to and including 3-inch size, the largest pipe that is usually made buttwelded.

Prior to 1886 wrought iron was the material universally used for welding pipe and other welding operations. The demand for a more uniform and more economical material for pipe manufacture led to experiments in the use of Bessemer steel for this purpose at the old Riverside Iron Works, Riverside, W. Va. Open hearth is now sometimes used, but it is somewhat more difficult to control in respect to welding quality, therefore it is perhaps fortunate that these early experiments happened to be made in a plant where only Bessemer steel was available, as Bessemer steel has since proven to be better adapted for standard pipe than open hearth or other grades of steel. From this time on the use of steel pipe has steadily increased until it now forms over 90 per cent of the entire production of wrought pipe in this country. Much has been done towards more uniform quality of product and increased production of steel pipe through the building of complete pipe producing plants, wherein the pipe is made complete from ore to finished product The influence of uniformity on durability was recognized and improvements in the method of rolling were introduced to produce a more uniform working of the metal in rolling the skelp from the bloom. Most of the work in rolling the ingot into skelp is naturally done lengthwise. By means of a special design of knobbed roll the bloom was subject to lateral work while being elongated and reduced in section which rendered the metal more uniform in density and therefore in better condition to resist corrosion.

The experiments which led up to this treatment were made on an old three-high skelp mill at McKeesport on which the middle tongue roll was deeply grooved. The faces of the projections had an angle to each other of about 100°. The blooms should be heated to a comparatively high and uniform temperature and all loose scale removed by a jet of steam or water during the rolling. This process was later applied to continuous skelp mills and was determined "roll-knobbling" by the author, but by mill parlance became better known as "Spellerizing." Later, as a result of our study of the various factors which came into the complicated problem of corrosion, the influence of mill scale on pitting of steel became recognized and means were sought to remove the heavy scale which forms in welding pipe. A process was soon developed through experiments made in the mills of the National Tube Company for the removal of this scale from the hot pipe.*

More Recent Developments.

The standard method of finishing pipe consisted in giving the pipe one pass through a circular sizing roll and one pass through straightening rolls of helical section and then cooling on a traveling table.

The finished pipe was covered with a rather heavy mill scale which forms in the heating furnace at the welding temperature. This scale consists essentially of iron oxides, principally Fe_3O_4, with 7 or 8 per cent of silica and smaller amounts of C_2O and Al_2O_3 from the furnace bottom. At the welding temperature this scale is fluid and forms a natural flux for welding, as well as a protection to the metal against excessive oxidation from the furnace gases, so that this is a very essential factor in the welding of pipe, so much so that pipe steel is made primarily so that it will be self-fluxing by readily forming this fluid oxide at as low a temperature as possible. Wrought iron carries considerable excess of fusible slag and oxides intermixed with the metal, whereas pipe steel, when properly made, readily forms a suitable fluxing scale when heated to the welding temperature. The melting of the welding scale affords the welder a sharp indication of the temperature of the skelp, which is much better than any pyrometer for this purpose. On cooling, the welding scale passes through a viscous stage and then quickly becomes brittle at a temperature at which the steel is still quite easy to forge. Most of the scale on the outside is removed in the sizing and straightening rolls, but inside the pipe this scale is often 1/32 or 1/16 inch thick in patches, and when cold is firmly attached to the metal like an enamel. Several means have been used to remove this scale to prepare the pipe for galvanizing and other coating operations. Pickling in acid is the most common method employed, but is the least effective on the inside of pipe where the scale is most firmly attached and, further, as the scale is very irregular and rather thick in spots portions of the metal are likely to be damaged by over pickling before all the metal is cleaned. Mechanical cleaning by sand blasting and cold rolling has been tried, but has not been thorough enough, besides being quite costly.

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*Much of this information on historical development has been obtained from a thesis on Buttweld Pipe, by C. D. Terry, assistant to general superintendent National Tube Company.

*U. S. patents granted to F. N. Speller covering scale removing equipment:

1,149,696—Welded pipes. August 10, 1915.

1,149,697—Methods of making Buttweld Pipes. August 10, 1915.

1,171,757—Method of finishing welded pipe. February 15, 1916.

By making the diameter of the pipe larger and then reducing the size and elongating the pipe at the highest temperature at which the scale is brittle enough to remove, it has been found possible to clean the pipe in the process of hot finishing and at the same time produce a better material in other respects. This new process of finishing is very advantageous. It will be seen that two additional steps are introduced in the finishing operation in order to produce what is practically a scale free pipe, (1) a partial cooling from about 2,500° to 1,800° F., (2) a reduction in diameter and elongation of about 10 per cent in length by means of a series of horizontal and vertical rolls, by which the brittle scale is cracked and separated from the steel. The pipe is then straightened and cooled as usual, during which a thin film of new oxide forms sufficient to protect the metal from rusting while being handled. A thin coating of suitable lacquer is now applied, which affords substantial protection to the pipe in storage. The main object of these scale removing and cleaning operations is to make possible more uniform galvanizing. This also has an important bearing on the manufacture of all kinds of coated pipe and conduit for electrical purposes.

The scale free surface rusts much more uniformly than when covered with the heavy mill scale, as there is quite an appreciable current generated between mill scale and iron which results in pitting of the metal. For this reason it is usually of advantage to have the scale removed, especially where the pipe is buried in the ground or subject to other active corrosive influences. The fact that mill scale is usually the controlling factor with respect to pitting of iron and steel has been demonstrated by several other investigators besides ourselves. Some tests made in hot water service at Harvard University recently covering a period of three years indicate that this scale free pipe was pitted to little more than half the depth of pitting found on the regular wrought iron and steel pipe used for comparisons in this test.* It may be said as a rule that the more perfectly the surface is cleaned the more uniform will be the corrosion. This is the reason that such care is desirable in the removal of scale and dirt before painting iron or steel. The scale removing process described was first developed in 1913 and has recently been put into general use in the buttwelding mills of the National Tube Company.

In hot galvanizing a saving of considerable time and about 50 per cent of the acid has resulted from the use of scale free pipe as well as a much improved product, particularly with respect to the inside coating.

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*Prof. M. C. Whipple, *Journal N. E. W. W. Association*, March, 1920, page 42.

NEW DRIVER-HARRIS ROLLING MILLS

E. Cooper Willis, who has been engaged as general superintendent of the hot mills and engineer of the Driver-Harris Company, Harrison, N. J., has been in Pittsburgh recently completing the purchase of equipment for the new rolling mill plant on which the company is about ready to start construction. The mill building, which is of all steel construction, 275 ft. long, 100 ft. wide and 22 ft. in the clear, is to be fabricated, erected and completed by the American Bridge Company. The building will be equipped with a 20-in. break down and plate and sheet train, one 9-stand 9-in. mill for wire rods and merchant mill products, four modern type heating furnaces and two electric annealing furnaces. The 20-in. mill is to be driven by an 800-hp d.c. motor and the 9-in. mill by a 500-hp d.c. motor. A motor generator set for converting alterating to direct current also is part of the equipment. The mills will run on 600 volts and have a speed ratio of 600 to 300, this flexibility being required on account of the character of the products the company produces.

In addition there will be an open hearth plant constructed. At present the Driver-Harris Company ore operating two Herault electric furnaces. The open hearth will be used for carbon steel, electric furnaces being used for alloy metals.

The products include nichrome, Monel metal, brass and various carbon steels. M. Hoagland Sons & Co., Rockaway, N. J., has the contract for building the mills. The Westinghouse Electric & Manufacturing Company and the General Electric Company will furnish the motors and generator sets, and Fawcus Machine Company, Pittsburgh, the drive for the 20-in. mill. Mr. Wills formerly was general superintendent and engineer at the Rahway, N. J., plant of Nagle Steel Company, and the layout and design of the new plant of the Driver-Harris Company is entirely in his hands. When completed he will become general superintendent of this plant. F. L. Driver is president of Driver-Harris Company and Leon O. Hart general manager.

LIGHT ARGENTINE STACK.

What is believed to be the first blast furnace to be put in operation in Argentina has been lighted near Jujuy, Consul Wilbert L. Bonney has reported to the bureau of foreign and domestic commerce. Near Jujuy are deposits of both iron and lead ores. The furnace project employs 90 men and is producing about 24 tons of pig iron a day.

The Logic of Roll Design

Describing in Detail the Design of Rolls for Guide Mills and Part of the Formula in Use Today on This Work.

By **W. H. MELANEY.**

PART VI.

THE design of rolls for producing ordinary merchant bars such as rounds, squares and flats, presents no difficulty and is subject to simple rules easily applied when understood.

Most of these are rolled from a square billet of a size to suit the diameter of the rolls on which they are to be rolled and then reduced in the roughing rolls to a billet of the proper size to make the particular bar desired.

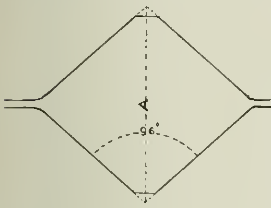


FIG. 1-B

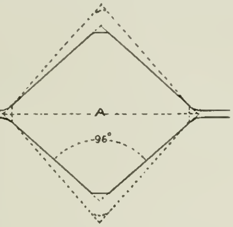


FIG. 1-C

As stated in a previous article, the roughing rolls are usually of the open square type of grooves with perhaps one or two box passes where the billet is of large size for that particular mill. An open square groove under this condition would reduce the diameter at bottom of the groove to below the size of the neck, due to its being placed in the roll diagonally.

An open square groove is the ideal method of reducing billets of six inches square and under, as it permits the production of any size of billet that may be required within close limits and also permits the squaring up of the billet by returning it through the same sized groove after giving it a quarter turn. It does not, however, permit the maximum amount of reduction to be used.

Where rapid reduction is desired in order to reduce a larger billet to small size as in the production of small rods or bars, use is made of a flat oval groove in connection with the open square groove, the billets being entered flat into a comparatively shallow oval groove and then edged up into a much smaller square groove again. This process is continued until the desired size of billet is provided from which to make the finished bar.

This type of rapid reduction oval should not be confused with an oval for producing a finished guide round, as the reducing oval is much shallower and wider.

Designing Open Squares.

The usual method of laying out open square grooves

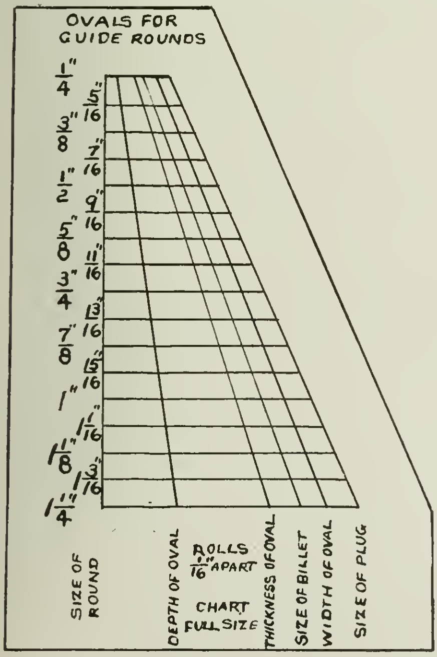


FIG. 2

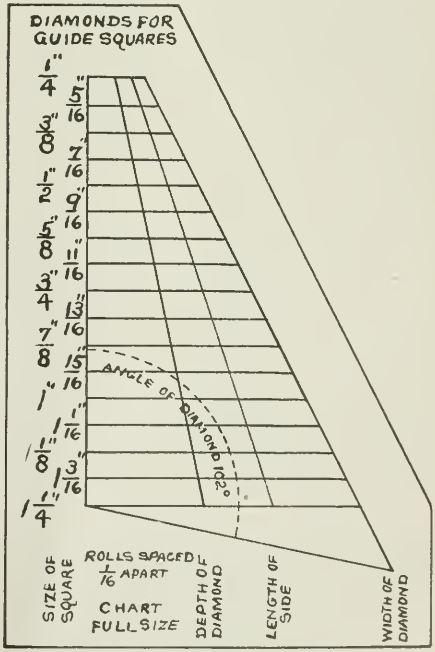


FIG. 3

is to mark off on the center line a space equal to the diagonal of an open square, six degrees open and of a size sufficient to permit the billet you have decided to use to pass through without overfill (Fig. 1-B.) Then set the compasses the width of the vertical diagonal of the open square (Fig. 1-B) and use this for the horizontal diagonal of the next groove (Fig. 1-C) as shown at A, this gives the maximum reduction that can be produced on a groove of that size and opening. The overfill is prevented by the fillet at bottom of groove as shown in illustration; this process is continues from groove to groove until the minimum size of billet required is obtained.

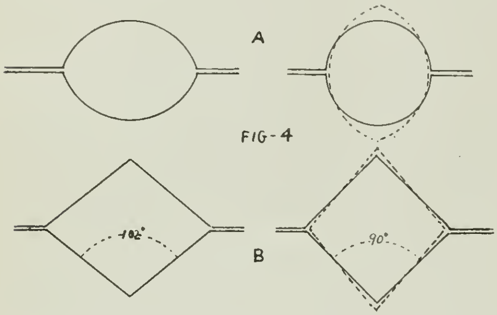


FIG-4

Of course, where a particular size of billet is required from any groove, the width of the groove on the center line may be made to suit the requirement, provided it is not less than the vertical diagonal of the preceding groove, but may be as much wider as necessary. The wider the groove the less the reduction will be.

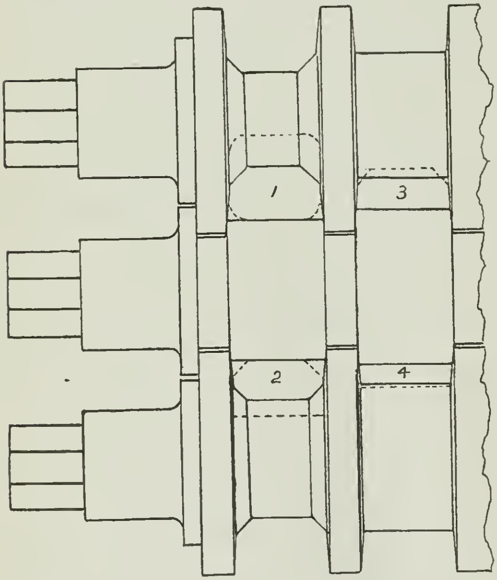


FIG. 5

Rolling Round or Square Rods.

Now if a small round section is desired for the finished product a size of billet is selected from the roughing rolls and further reduced in the strand rolls by means of reducing ovals and open squares until a square billet approximately the size of the finished round is obtained. This is then entered flat into an oval groove for the purpose of shaping in and flattening it so it will enter the round finishing groove, the oval groove at the same time finishes the two sides of the bar that will be opposite the open spaces between the top and bottom finishing rolls. The oval is then edged up into the round finishing groove and has just sufficient cross section to slightly overfill the round groove, but overfill is prevented by slightly underfilling the oval as sharp edges on the two edges of the oval, which would result if the oval was completely filled up, are not desired. The thickness of the oval must be less than the diameter of the finished round to allow for sufficient spread, without marking the sides of the round where the break between the rolls occurs. In other words, just permitting the round groove to evenly fill up. (See Fig. 4-A.)

If a finished square section is desired instead of the round rod the same operation is followed, up to the production of the proper sized billet to make the square. This is then given a pass through a diamond groove, usually having an angle of 102° or 12 degrees open, thus flattening the billet sufficiently to enter the finishing square groove and at the same time finishing the two corners of the square that will come opposite the space between top and bottom rolls in the finishing set. This diamond is given a quarter turn and edged into the finishing square groove, sufficient spread having been allowed to prevent any overfill. The square groove simply finishes the other two corners of the bar and shapes it up to a 90-degree angle of the square desired. (See Fig. 4-B.)

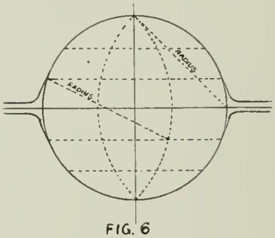


FIG. 6

Where Charts Can Be Used.

The sizes of ovals and diamonds for the various sizes of rounds and squares are proportional and can therefore be definitely laid out from a chart such as shown at Fig. 2 and Fig. 3.

While there may be a difference of opinion among roll designers as to the exact shape the oval or diamond should be, some preferring a shallower and wider groove while others prefer the deeper and narrower ones, this is simply a matter of opinion. The essential features are that it contain enough cross section to just fill the finishing groove when the oval or diamond is properly filled up by the billet and have enough spread to take care of overfill.

The less the spread that can be used without overfill the less the scale will be broken on the two sides of the round or square which are finished in the oval or diamond grooves and the nicer looking the finished rod will be. The charts shown are based on present day practice.

Rolling Rectangular Bars.

Where simple rectangular bars, commonly called flats, are to be rolled, the usual process of reducing the billet to the proper size is followed the same as for rounds or squares.

It is obvious that a slightly smaller square billet than the width of the flat is required for exactly the same reason as stated in the preceding process, namely to provide for spread.

This billet is then reduced in thickness only, usually getting three or four passes in tongue and groove rolls with positive width of grooves and with a slight taper in the sides of the grooves and just sufficient spread to prevent overfill and insure free delivery of the bar; this taper in thick flats amounts to from one to one and a half degrees in each side of groove and on thin flats to two and one-half degrees, while on grooves for rolling hoop it would be twice this much. This is to allow easy delivery on thin flats which otherwise might stick and buckle up in the groove. It also permits the grooves to be brought back to width when rolls are re-turned.

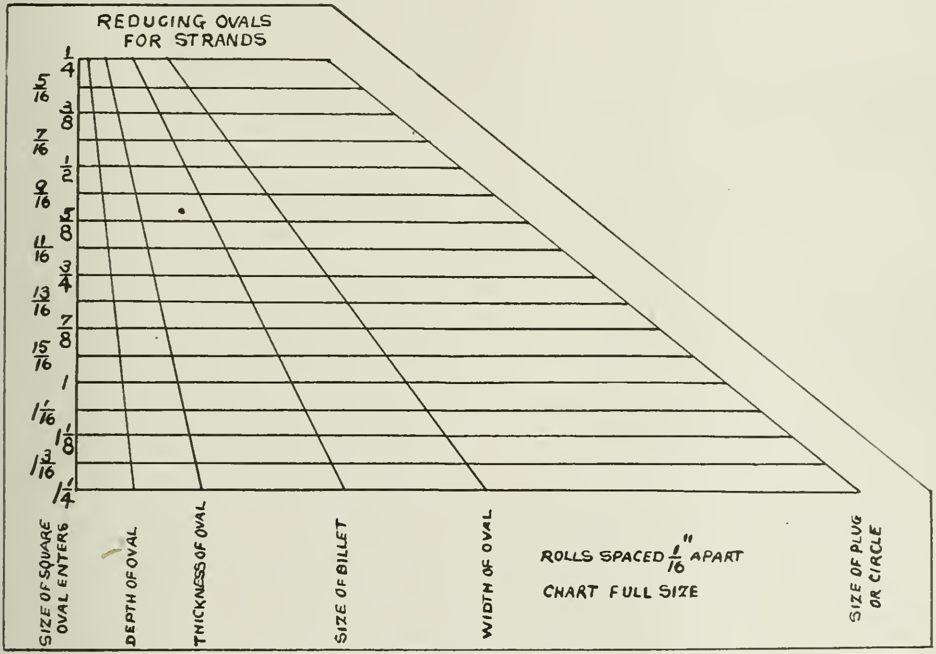


FIG. 7

On flats the main essentials are that all four corners of the bar be filled up sharp, that the edges of the bar be a right angle to the top and bottom of the bar and that provision be made to prevent overfill.

The overfill is prevented in this case by using sufficient fillet in the bottom of the first groove to prevent the heated metal squashing up between the tongue and side of the groove on the next pass. Any tendency to overfill on the first groove being amply taken care of by the rounded corners of the billet as it comes from the roughing rolls. (Fig. 5.)

The pass before the finishing pass should have sharp corners the same as the finishing pass, otherwise it would be difficult to get the corners sharp on the finished bar as the reduction on the finishing pass is light.

It is apparent that the side of the bar that has its corners filleted off in one pass must be so entered in the succeeding pass that these filleted corners will be next to the tongue and thus by leaving an open space prevent any possibility of the metal squashing up between the collar and tongue of the groove.

On flat rolls of the tongue and groove type, the bulk of the reduction is on the first pass, as a square billet is usually used for ordinary sizes, but an extra pass is sometimes used to flatten the billet for large sizes.

Other methods of rolling flats, especially from high carbon steels, will be described in a future article.

Hand Rounds and Squares.

Another method of producing rounds and squares which are too large to roll by guide on the mill it has been decided to roll them on, is known as hand rolling.

By this method only short bars can be rolled successfully, usually not longer than 20 feet, as the operator must retain his hold upon the bar until the last end of the bar almost reaches the rolls, especially in the case of hand rounds. This is to prevent any tendency of the bar to turn or twist during the time it remains in the rolls.

In hand rolling, instead of getting one pass in the finishing groove, as in the case of guide rolling, it usually gets four passes, the bar being given a quarter twist after each pass before being re-entered in the groove. Such bars are rolled on two-high rolls, the bar being pulled back over the top roll after each pass.

A square billet is used to start with, but is partly shaped up in a leader pass which is usually one of the larger grooves in the same rolls.

The rolls have as many different sizes of grooves for standard sizes of rounds or squares as the length of the rolls will permit, the two end collars being left several inches wide to prevent interference of the tongs with the sides of the housings.

Slowing Down Speed for Hand Rolling.

In hand rolling as the operator retains his hold upon the bar it is necessary to slow down the mill while doing this work and for this reason more than one speed is required. The electric motor with a variable speed is nicely fitted for this work.

Designing Grooves for Hand Rounds.

In designing grooves for hand rounds, the grooves are cut away or opened out where the parting between the rolls occurs and the corners of the grooves are also rounded to prevent any danger of marking the bar while rolling.

By giving the bar four passes in the finishing groove with a quarter turn of the bar at each pass, the bar is almost perfectly rounded. Fig. 6 shows one method of determining the opening in a hand round groove that is considered good practice.

A hand square is rolled similar to a hand round except that the groove is square with the corners nicely rounded. The groove is also made about one degree open square.

Errata.

An error occurred in the table accompanying the article on "The Logic of Roll Design" which appeared in the September issue of The Blast Furnace and Steel Plant magazine. Under the table for guide or bar mill rolls, the letter at the head of each column was transposed and was not in accordance with the roll sketch shown in another part of the article. They should have been in the following order, A G H C B F D E R, instead of the order in which they were printed.

Gas Producers for Bituminous Coal

Expression of Opinions and Conclusions, After a Number of Years of Study and Operation of Gas Producers—The Points to Be Studied to Secure Good Results Are Outlined.

By HENRY WILLIAM SELDON,
See-Seldon and Associates, Engineers.

THE theory of gas producers and producer gas making has been repeated many times and for such a discussion we would refer anyone to Carl Dichmann's book, "The Basic Open Hearth Process," or some other good authority.

In the following article we will confine ourselves to the expression of opinions and conclusions arrived at as the result of a number of years of study and operation of gas producers.

The term bituminous coal is very broad and we would advise a complete survey of the available coal before installing any make or type of producer. Locate the best coal available for producers and then bear in mind the sad truth that sooner or later you may be compelled to use a poorer grade, temporarily at least. In other words, do not install just sufficient producer capacity and expect to have ideal conditions at all times.

Bituminous coal for gas producers is usually offered for sale by its analysis. A coal having the volatile matter over 30 per cent and an ash content under 10 per cent is sold as a good gas coal. We have found in addition to these analyses it is important to know the amount of sulphur and moisture present as well as the melting point of the ash. Likewise the physical condition of the coal is very important when the amount of coal that can be gasified is being considered. By this is meant the size of lumps, percentage of fines and hardness of the coal. In selecting gas coal aim to get the best coal available in your locality and insist upon the following:

Volatile matter 30 per cent or better.
Ash as much under 10 per cent as possible.
Sulphur under 1 per cent if possible.
Moisture low as possible.
Melting point of ash high as possible.

For the ideal physical condition we prefer the coal which passes through a 2" mesh and remains on a ⅜" mesh. Gas coal containing not over 25 per cent of fines is not objectionable. We have a preference for hard coals.

When a certain rate of coal gasification is mentioned it is important to know the kind of coal and its physical condition. The best test of any gas coal is a trial in the producer.

We do not want to create the impression that low grade gas coals cannot be used in gas making, for they can, but we do want to emphasize the fact that some coals make more and better gas than others and that good coal is necessary if the commercial rating of a gas producer is to be obtained.

Sample analyses of the gas coal used in this district are as follows:

	No. 1	No. 2	No. 3	No. 4
Volatile matter	35.52	33.00	33.60	31.53
Fixed carbon	53.31	57.82	58.28	58.55
Ash	11.17	9.18	8.12	9.92
Sulphur	2.82	.85	.92	.96
Phosphorous	.010	....	....	.024

Sample analyses of ash from producers using the above coals are as follows:

	No. 1		No.2
	Hand Poked—	Mechanical	Hand Poked
Volatile matter	1.12	1.49	.78
Fixed carbon	4.13	12.71	5.24
Ash	94.75	85.80	93.98
Sulphur	.13	not det'd	.08

	No. 3 Hand Poked	No. 4 Mechanical
Volatile matter	.56	1.00
Fixed carbon	4.28	22.41
Ash	95.16	76.59
Sulphur	.05	not det'd

The objections to a low grade or inferior gas coal are as follows:

Cuts down the rate of gasification which in many cases means a shortage of gas on the furnace; necessitates a higher steam pressure with the accompanying wet gas and producer troubles; cuts down the quality of the gas produced and reduces the producer efficiency.

There are a great many makes of gas producers on the market. They differ in their detail construction or method of operating, but the basic principle and design is the same. In general the construction consists of a vertical cylindrical steel shell lined with fire brick with means provided at the top for the admission of coal, means provided at the bottom for the removal of the ash, a hood or distributor inside which introduces the blast (steam and air mixture) and an outlet pipe likewise fire brick lined for conducting the gas away.

This is virtually the description of the hand operated type of producer and we find many in use. With this type of producer the results obtained depend entirely upon the operator. It is possible to make a gas just as rich and for all purposes just as good as can be made in any mechanical producer, but the difficulty exists in obtaining a good gasmaker who can or will operate them. In addition to the labor proposition there are numerous other weaknesses which have all been instrumental in assisting the development of improved designs. Perhaps the weakness which has led most of all to mechanical producers was the desirability and difficulty of maintaining a thick fuel bed on the stationary hand poked producer. This condition led to the development of mechanical agitation and rotating of the producer body.

With the advent of the rotating producer came the mechanical removal of the ash.

The value of a uniform and continuous coal feed was recognized and its development started.

With the mechanical producers advent came increased coal gasification per unit and larger units.

The distribution of the blast inside the producer has received attention and much benefit has been the result.

In the early development of the mechanical gas producer certain mechanical features and principles were discovered and patented; a condition which still exists and which accounts for the numerous different makes of producers on the market. But the fundamental principles of producer gas making are still the same and each manufacturer is trying to approach the automatic production of producer gas by mechanical means.

This we have in operation:

1. Stationary producers which are entirely hand operated, i. e., the coal is fed by hand, the producer is poked by hand, and the ashes are removed by hand.

2. Stationary producers which are partly operated by hand, i. e., the poking is done by hand and the ashes are removed by hand, but the coal is fed automatically.

3. Stationary producers in which the coal is fed by hand and the poking is done by hand, but the ashes are removed mechanically.

4. Stationary producers in which means are provided for mechanically agitating the fuel bed, coal is fed by hand on some and mechanically on others; ashes are removed by hand.

5. Mechanical producers in which the main body of the producer rotates; means are provided for mechanically agitating the fuel bed; the feeding of the coal and the removal of the ash are either done by hand or done mechanically.

6. Full mechanical producers in which all the operations are done mechanically; the fuel bed is automatically agitated; the coal is fed and distributed mechanically; the ashes are removed mechanically; the body of the producer is mechanically rotated.

Under each one of the above types of producer there are many different makes of producers and each one claiming some advantage or superiority over the others. The points of argument usually resorted to are as follows:

1. The amount of coal the producer will gasify per hour.

2. The quality of gas which the producer will make.

3. The amount of steam required per pound of coal gasified.

4. The repair costs and the speed at which repairs can be made.

5. The cost of installation.

6. The efficiencies of the various portions of equipment, such as the method of agitating the fuel bed; the particular type of blast distributor; the method and value of the ash removing scheme; steam or turbo blower or both; amount of labor required to operate, etc.

There are scores of different makes of gas producers in operation and you will find some operators in favor of each one.

The question naturally arises, "Which is the best?" to which we are compelled to answer by asking the question, "What are the requirements, conditions and finances?" Without this information we cannot say.

We offer the following general advice:

Be sure to get ample producer capacity.
Be sure your installation is properly made.
Get or train a competent producer operator.
Buy good gas coal.
Provide ample dry steam.

Coöperate with your gas maker and learn something about gas making as you do about your other operations; it will be helpful to you.

It is surprising the lack of practical knowledge among managers and superintendents regarding the art of gas making. This may be caused by the dirty and undesirable condition in the gas house and the class of foreign labor employed there, but it certainly is not excusable. If this were not the case many gas house troubles would never materialize and some of the furnacemen's excuses would disappear.

There has been a great deal of theoretical written and oral discussion on producer gas and the efficient operation of gas producers, but we have found the practical knowledge absolutely essential.

Our idea of the most efficient operation for any gas producer is that operation which *produces the best results on the furnace.*

FOCH IS EXPECTED

Although cable advices from Paris have stated that Marshal Foch had accepted the invitation of the American Iron and Steel Institute to be its guest at the fall meeting in New York, no official word from the former has reached the offices of that organization. Originally it had been planned on October 28. Before making any final decision, however, the institute will consult Marshal Foch as to what date will prove most convenient for him to make the visit.

New 600-Ton Blast Furnace Plant

The Trumbull-Cliffs Furnace Company New Plant at Warren, Ohio, Now Completed—Many Interesting Features Constructed in This Plant—Record Time Made on Construction Work.

THE new 600-ton blast furnace plant of The Trumbull-Cliffs Furnace Company was completed on June 14, 1921. Work on the plant was started August 15, 1920. On that date the site was an open field on the Mahoning river across from the Trumbull Steel Company and without railroad connections. In one day less than ten months the material and equipment was erected and placed in position, the tracks in, the yard graded and fenced in, machinery turned over and plant ready to make pig iron—in short, everything completely finished. This is record time for construction of a complete blast furnace plant.

The plant arrangement is laid out for future installation of additional blast furnaces as well as for a by-product coke plant. Throughout the design, provision is made for extension without interruption at the pumping, power and boiler houses, furnace and cast house, stock house and stock yard, casting, switching and other operations. Moreover, an extension of water lines, sewers, transmission lines, tracks, stock house and stock yard developes with minimum expense and effort from existing units. As a typical example of provision for expansion, the boilers are so designed with high settings and distinct combustion chambers for gas and coal firing, that stokers may be installed in the existing settings and the electric power output of the plant increased up to 12,000 kw.

Throughout the plant the professional man as well as the casual visitor is impressed with the exceedingly careful study devoted to details, the coördination of groups of allied occupations, provisions for safety, cleanliness and easement of conditions of labor and the provisions for elimination of hand labor in the handling of raw materials, products and waste.

The plant is especially notable for having embodied in its design all the proven and sound elements developed in years of American blast furnace plant construction and operation, and in addition many improvements which experience of the last few years has taught. These new features are not experimental. On the contrary, they go to make up a fully reliable plant built on accepted and conservative lines. Every guaranty is embodied that goes to insure good tonnage, economical practice and continuous operation. The plant is remarkable for the absence of the crudities such as usually accompany design and building for rough manufacturing such as blast furnace operation is usually assumed to be. Considerable attention has been given to appearance and there has been a successful application of architectural design to offices, power buildings, trestles and bridges so that they present a dignified and pleasing appearance.

The layout of the plant is apparent from Fig. No. 1. Present rail connections are the Pennsylvania and Erie railroads across the Mahoning river, but an additional connection is to be provided in the future at the opposite end of the plant by the Baltimore & Ohio railroad. As will be seen, the plant is laid out primarily for delivery of hot metal to the mixer at the open hearth building of the Trumbull Steel Company, and for the time being all raw materials are routed into the plant over the three-track reinforced concrete bridge which also serves as the delivery track for hot metal to the Trumbull Steel Company.

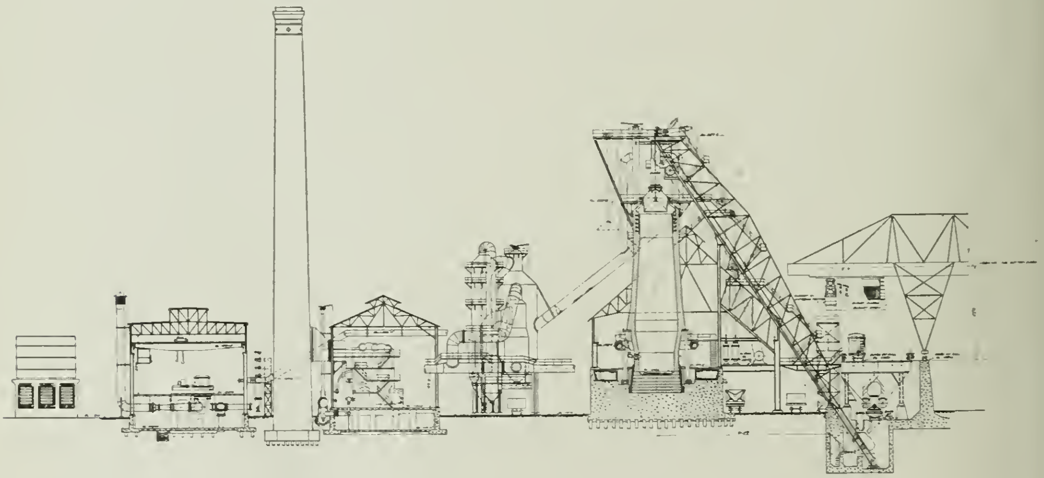


Fig. 1—Section through the new plant.

Approaching the plant over the bridge affords a most comprehensive view of the entire layout. As one goes through the plant, he is impressed with the substantial construction, with the completeness of the equipment and the new appliances and practices introduced to better the practice and economy of operation. A new feature is to be found in the provision for screening of the coke at the furnace bins. This consists of two rotary grizzly screens, each screen having eight motor driven shafts. These shafts carry discs, and the shafts and discs are so spaced that the rotary grizzly removes material under ¾" in size. The flow of coke from the bin to the grizzly is controlled by a cut-off gate and also by a rotary vane feeder. This provides a steady and even flow of coke over the grizzly. Emergency operation is provided for in a gate and a dead plate furnished over each grizzly so that coke may be by-passed direct from the bin to the skip hoist bucket in case the grizzly is out of operation. Underneath each grizzly is a hopper, one hopper delivering braize direct to a braize elevator, the other delivering braize to an 18" belt conveyor discharging to the braize elevator boot. The elevator is a belt and bucket type delivering to a 24-hour capacity bin. The motors driving the rotary grizzlies, the feeders and the belt conveyor and elevator are electrically interlocked so that the motor driving the vane feeder and belt conveyor cannot be started until the motor driving the rotary grizzlies and the belt and bucket elevator is running. There is also provided a 20% speed variation on the motors operating the rotary grizzlies.

The arrangement of cast house is the next outstanding feature. The cast house is very modernly constructed and has a 94'6" span, 4-motor Cleveland Crane & Engineering Co. crane of 25-ton main hoist capacity, with a 5-ton auxiliary hoist. It spans not only the cast house proper from the foot up to the furnace front, but also spans two tracks, one of which constitutes the hot metal track and the other a track for spotting of cars, for removal of scrap and rubbish, and for unloading into cast house of coke braize, clay and sand. This same crane is also utilized at the slag granulating pit at the foot of the cast house and for this purpose is equipped with a Hayward 1½ cu. yd. bucket, having perforated bowl and manganese steel lips. The crane serves to unload from car or truck and places upon the skip hoist house platform, the motor armatures for the skip hoist or other material required. In the cast house is a brick and concrete structure providing storage for sand, clay and coke braize, in which there is also provided a mixing room for the preparation of these materials.

Convenient access is provided not only by means of stairway, but also by means of an easy incline up the stove foundation to the cast house floor. The grouping of a number of allied operations which must of necessity come under the eye of the blower at the furnace is very noteworthy at this point. The stove platform is at practically the same elevation as the cast house, the cast house being reached by an easy incline not over 2 ft. in height from the stove platform. The stock bins are easily reached by a walkway from the cast house. This walkway passes the skip hoist house where the skip hoist, bell operating cylinders, and distributing mechanism are placed, and also passes the skip incline proper. The blower foreman is thereby able to watch not only the work in the cast house and about the furnace, but, without getting more than a few steps from the cast house, he can always check up on stove practice, or by watching the skip buckets, on the regularity of filling.

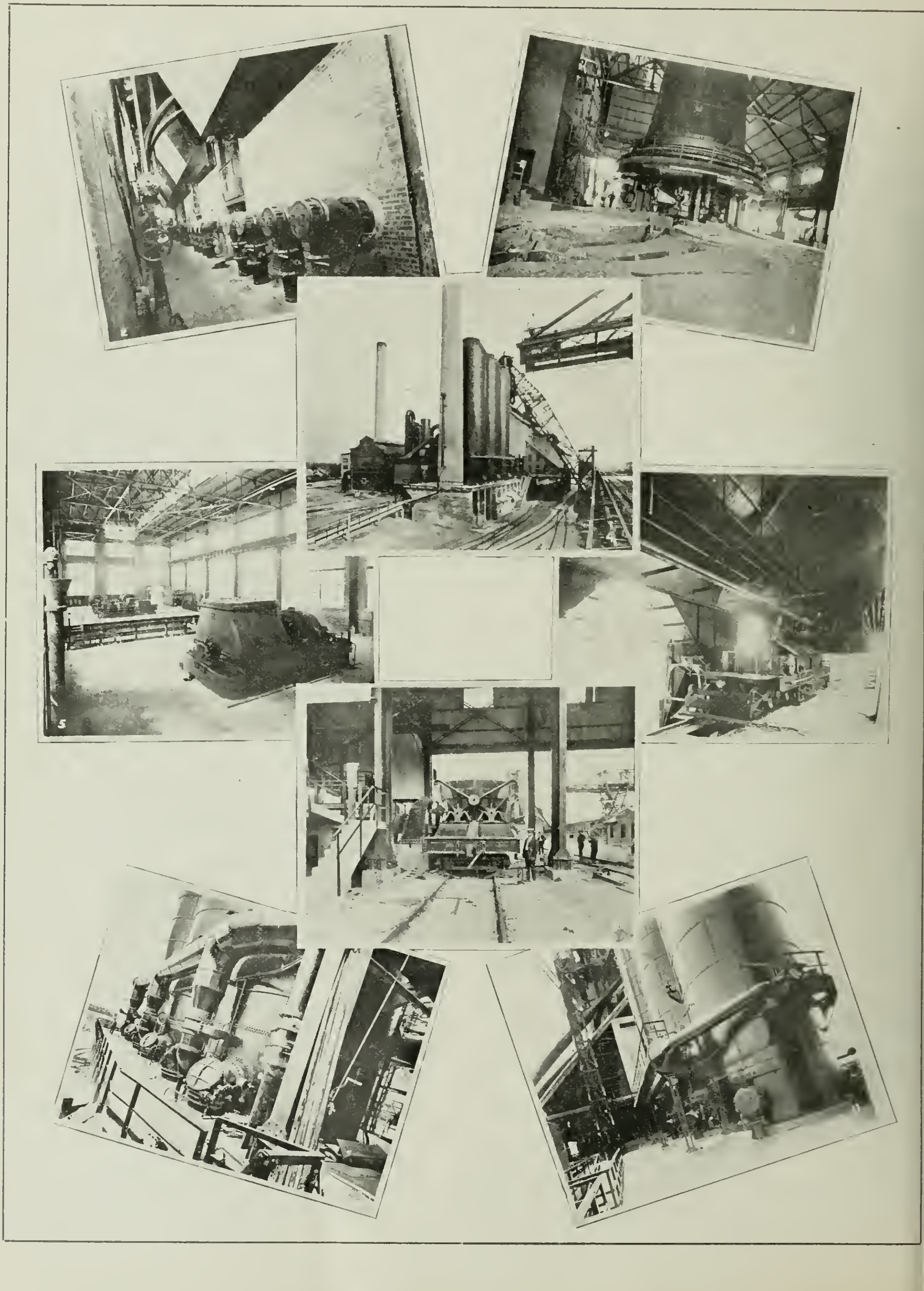
Provision is made so that the furnace can be rodded from the cast house as a check upon the men in the stock house. The shutters in the iron runners are opened and closed by steam cylinders, these being operated from the central control station at the furnace front where the snort valve wheel, the control for the Berg mud gun and signal apparatus are located as one unit. The cast house is supplied with a complete set of blast furnace tools designed by the engineers.

A new type of boiler setting has been installed by the engineers as shown in Fig. No. 6. This provides a high setting of the boiler and gives an exceptionally large volumetric space per bo. hp for complete combustion either of blast furnace gas or solid fuel. The gas burners, consisting of four 14" Birkholz-Terbeck burners, are installed at the back of the boiler. The combustion chamber for gas is under the mud drum, there being provided a distinct combustion chamber of large volume for the burning of the blast furnace gas without dilution by excess air through grate bars, or restriction of combustion by insufficient space, as in the usual setting. At the front of the boiler, grates are provided for auxiliary hand firing. The boiler is so designed that if increased power generation is desired stokers may be installed in the place of ordinary grates, without any work being done on the boiler other than simply building on a Dutch oven extension. The design has proven to have several very important advantages; it enables the boiler to be run at very high efficiency due to complete combustion obtained in the large volumetric space, it enables considerable overload to be carried on boiler due to the generation of high temperatures, and it minimizes the difficulties due to encrustation of the tubes with dust or ash.

In the power house considerable advance in design is shown. Special attention has been paid to daylight lighting. Ample floor space is provided and the engineers have incorporated all the successful features of modern power plant design. These are described in detail in another part of the article, but special mention should perhaps be given to the high intakes provided for the turbo blower, the advanced type of turbo blower installed, the completeness of the electrical equipment, and the well worked out system of water circulation and re-use.

In the blast furnace proper the engineers have designed a furnace which represents the best development in recent years with similar stacks built by them. The arrangement on the furnace top has been very materially improved as regards safety and convenience in work. The mantle and column has been increased in section and the manner of hanging the circle pipe, discharge trough and bustle pipe has been improved. An auxiliary cinder notch is provided. The iron and steel work of the furnace is so designed that the furnace can be enlarged at succeeding blasts if it should be found advisable. Other matters that are described later, but which should received particular mention, would be the evident care devoted to economy in quantity of concrete in the foundations, trestle approach, highway bridge and pig casting machine; and the new type of cantilever skip incline which affords greater rigidity of construction, and increased room in the cast house and on the furnace top.

Particular mention should be made of the improved gas main system which originated with Mr. D. T. Croxton. Contrary to the usual arrangement where gas mains are led overhead both at the boilers and stoves, the Trumbull-Cliffs gas mains are placed underneath or outside of the stoves and boiler house. At the stoves the large gas main from the gas cleaning plant goes to a water seal separator whence it is led along the piers of the skeletonized stove foundation. From this main pipes are led directly up through the stove platform to the stove gas burners. The main is given a slope which makes it easy to clean. On the boiler house side the large gas main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from the cleaning plant goes to a similar water seal separator whence it is led along at about yard elevation outside of the boiler house between the engine and the boiler house. This main is also given a slope and provided with downlegs for cleaning. From this main individual leads are taken to each boiler, the pipe for the gas burners coming up through the boiler house floor. This arrangement of mains is conducive both to cleanliness of the plant, ease in cleaning of mains and freedom from gas about the stove operating platform and inside the boiler house.

The grouping together as one unit of all elements of gas cleaning, the very complete maintenance and repair shop, and the excellent provisions made for the housing of the executive, general office, chemical and police departments should also be given special mention.

Starting in with the receipt of raw materials, the ore and limestone are unloaded by means of a Mead-Morrison movable car dumper. This dumper has a 57-ft. cradle and a capacity of 320,000 lbs. and is guaranteed to handle 30 cars per hour. The cradle is provided with both dynamic and air braking and has a travel the entire length of the ore and limestone yard.

Spanning the yard is a Mead-Morrison 11-ton man trolley ore bridge. It has a capacity of 600 tons per hour from the dumping pile to the storage pile or from the storage pile to the bins. The method of handling the ore and limestone consists in the movable car dumper placing material in a concrete dumping trough beneath the shear leg cantilever of the bridge. The 11-ton bucket picks up the material and delivers it to the main storage pile under the span of the bridge, or to the stock bins, or to the 50-ton Atlas transfer car when the materials being handled out of the stock pile are not directly in front of the stock bins into which they are being delivered.

The ore bridge has a cantilever at the shear leg end of such length as to permit delivery by the grab into railroad cars on the track approximately 32 ft. from the foot of the shear leg. This enables ore buckets to be changed and also enables the ore bridge to handle repair work at the car dumper. It has a similar cantilever at the pier leg end so that the ore bridge can handle the skips when they have to be replaced on the skip incline. The bridge has a travel speed of 70 ft. per minute and is of the skewing type, permitting either the shear leg or the pier leg to advance five degrees ahead of the other. It is completely equipped with safety devices to prevent over-travel of either leg, to prevent over-travel of trolley, and is equipped with magnetic solenoid brakes and rail clamps for provision against high winds.

The stock yard is 270′ wide by 505′ long and has a storage capacity for 250,000 tons of ore and 80,000 tons of limestone. Operating upon the ore bins is an Atlas 50-ton capacity side dump electric ore car, equipped with air operated brakes, doors and car pusher arm. The bins are provided with a cross-over and suitable conductors so that the transfer car can work on either of the two tracks on the bins.

The ore bins were designed and installed by the Hoover & Mason Co. They consist of nine ore pockets having a capacity of 3,120 cu. ft. each, four limestone pockets having a capacity of 2,900 cu. ft. each, and five coke pockets having a capacity of 2,900 cu. ft. each. In addition there is one central double compartment coke pocket, each compartment chuting coke to the skip bucket over a rotary grizzly screen. The rollers underneath the limestone pockets are perforated for screening.

The scale cars are Hoover & Mason double compartment type, equipped with air brakes, air operated doors and dial indicating and recording scales. Turn-out tracks for the spare scale car are provided under one part of the reinforced concrete trestle approach, the other part of the approach being bricked in to afford housing for riggers' tools, blast furnace spares, etc.

The control station for the skip hoist is on the yard level in proximity to the skip incline so that the skip operator has a view of the skip pit, as well as of the skip hoist track and the furnace top. The same station houses the control for the bell operating cylinders, the McKee distributor, the grizzly coke screens and the bell indicating and rodding devices. Connection is provided to the cast house and furnace top by speaking tubes.

The skip incline is of the cantilever type. It is supported entirely independent of the blast furnace so as to avoid any side thrust on the shell, and is 171 ft. 6 in. long with double track for skip cars of the trailer truck type. Skips are operated by a Lidgerwood electric double drum hoist, driven by a Westinghouse 200 hp d. c. motor. The hoist has a rope speed of 300 ft. per minute and is designed for an unbalanced load capacity of 20,000 lbs. Cutler-Hammer control is supplied. This hoist is located in a concrete and brick house under the skip truss and above the tracks. This structure also houses the bell operating cylinders which are actuated by air from the cold blast main. An auxiliary air supply is provided from the high pressure compressor line, and this is automatically admitted through a pressure regulating valve in the event of drop in the blast line pressure. The control board for the McKee distributor is located in this house. This control is for six-station, six-cycle operation, but provision is made for installation of additional panels for different cycles of charging.

The furnace top is of the standard double bell Freyn-Brassert design, having also a McKee distributor. The design of the receiving hopper and throat is worked out to give correct distribution even when the charge is not revolved. The entire top of the furnace has solid plate guard rails and special attention has been paid to accessibility of all working parts and for observing the distribution of material in receiving hopper and for observing the dumping point of skip. Bleeders are provided with permanent rail platforms, as is also the outrigger. The outrigger is provided with a trolley for facilitating work of repair or relining. Access to the furnace top is by means of interrupted flight stairs up the skip incline and also by means of a bridge from the furnace top direct to the Otis elevator, and by a bridge to the stove top. An extra large door is provided as the gas seal.

The six-passenger Otis elevator is a worm geared traction type, having a capacity of 1,500 lbs. load, fully equipped with interlocking devices and emergency safety features. It has push-button control and four landings.

The furnace is 92′x22′6″ and has a capacity of 25,500 cu. ft. The iron and steel work includes a heavy continuous cast iron sub-base. The concrete foundation is reinforced by tension bands and the column base and columns are encircled by a reinforced concrete beam, extending between the columns up to within a short distance of the hearth jacket segments. There are ten cast iron columns and ten tuyeres, tuyeres being placed centrally between columns, thus affording good working room. The columns are offset, which not only allows more room for work about the tuyeres and places the columns and colbreakout, but affords the possibility of enlarging the fur-
breakout, but affords the possibility of enlarging the fur-

nace hearth and bosh in the future. The columns are one piece and entirely free from any cast-on iron lugs. The bustle pipe, circle pipe and waste water trough are suspended from the mantle. Special attention has been given the location of circle pipe connections and waste water trough overflow so that there is ample room on the bustle pipe walk and it is free from obstructions. The hearth jacket is of the standard Freyn-Brassert cast iron segment design, having cooling pipe cast in, and heavily wedged, banded and bolted. It is tapered, thus maintaining a safe thickness of hearth wall against erosion and breakouts and also maintaining ample brick at the bottom to prevent short holes and to prevent the hearth block from rising. The tuyere breast consists of a solid armor of 1½" plates with openings for the 10 tuyeres and for the bronze cooling plates. The bosh is reinforced with eight 1½" thick bands, the bands being held by cast steel distance pieces to prevent slipping. The mantle is of a specially heavy built-up plate angle construction and is provided with a trough with drainage provisions for collecting shell spray water. The furnace shell, which is especially designed to meet modern furnace lines, is of butt strap construction on both the two bottom rings and the top ring. The intermediate rings are of double lap riveted construction. The shell is surmounted by a dome on which the large bell hopper ring is riveted.

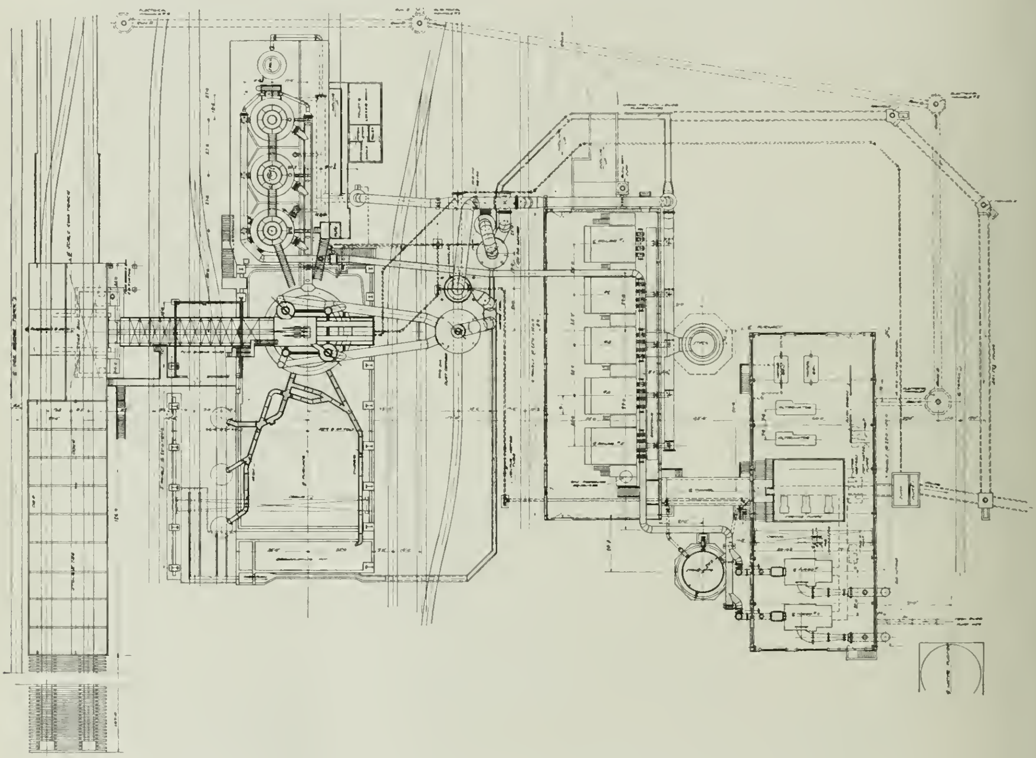

Fig. 12—General arrangement of Blast Furnace.

The furnace is lined with General Refractories Olive Hill steam pressed fire brick, the thickness of lining being heavier in the lower inwall, to afford maximum thickness where required, than in the upper part where an excessive depth of lining would be detrimental. No interior water cooling is given the lining above the mantle, but a permanent pipe spray with connection is affixed to the shell and a permanent platform is also provided at the spray. This platform is reached by a short bridge from the skip incline steps. A new design of bosh and tuyere breast plate is used, having baffles that give more positive circulation of water and enable the plate to be more easily withdrawn in the event of its becoming cracked or burned. The hearth walls are cooled by the cast iron cooling pipe of the hearth jacket, which extend approximately 9 ft. below the elevation of the tapping hole. The stock line is afforded protection by cast iron wearing plates of high combined carbon content. These plates are laid integral with the lining and are of small surface dimension in each unit.

The bustle pipe is insulated with Johns-Manville Vitro Fire Felt and easement against thrust against the columns by expansion of the hot blast main is provided in an expansion joint.

"Green" unlined tuyere stocks are used.

The hot blast stoves are three in number, with a total heating surface of 285,000 sq. ft. They are of the two-pass side combustion type of the standard Freyn-Brassert design. The stoves have a built in draft flue in the skeletonized reinforced concrete foundation, this flue leading to an 8'x225' Heine reinforced concrete stack, brick lined throughout. The stoves are equipped with blow-off valves turned down into the chimney flue, standard Freyn-Brassert equipment of quick closing chimney valves, gas burners and gate type hot blast valves. Provision is made for the future installation of an additional hot blast stove. These stoves have 3½" checkers with 2" checker walls, the design of checkers, arch and draft chamber equalizing the flow of gas down through the checkers, thus overcoming the usual tendency toward segregation of flow of gas in a limited number of checker openings. The stoves are insulated with Sil-O-Cel powder and brick and are lined with General Refractories fire brick; hand made inwall quality is used in the combusiton chambers and dome, and steam pressed inwall quality in the top of the checkers. The ring wall and bottom of checkers as well as draft chamber piers and arches are made of stove quality. The gas main leading to the stoves is equipped with a butterfly valve which is intended later on to attach to a new Freyn-Brassert design of gas pressure equalizing equipment to maintain constant pressure in the stove gas main.

The cast house, which is on the same elevation with the hot blast stove operating platform, is laid out to run cinder either to cinder ladles or to a cinder pit at the foot of the cast house. The iron runners are laid out to deliver to three 75-ton Pollock short-pour hot metal ladles. The runners have a fall of ⅝" to the foot to give a minimum amount of scrap. Coke dust, sand, loam, clay, furnace tools, copper, etc., are brought to the cast house, and the 25-ton crane, spanning the cast house, the hot metal track adjacent to the retaining wall of the cast house, and the working track outside of the hot metal track. The materials are placed in a permanent brick and concrete shed inside of the cast house. The equipment of the cast house includes a Berg-Brosius clay gun, which was specified not only as a safety measure but also for the purpose of keeping the blast on the furnace and gas on the boilers over casts. The working cinder notch is 45 degrees from the iron notch. An auxiliary cinder notch is provided, this being fitted up with a standard cooler and intermediate cooler so that cinder can be withdrawn here in an emergency. The shutters are all of the Fraser remote control type, and snort valve wheel, mud gun control and shutter control are all located at one point. Special lighting facilities have been provided and there are an abundant number of hose connections for both high and low pressure water. Steam and air are piped to the cast house for use on mud gun and for other casual requirements. For the purpose of communication there is a speaking tube from the cast house to the nearby operator's house and to the furnace top, and there is also a duplex signal apparatus connecting the cast house with the boiler house and power house.

The gas is taken off the furnace by four offtakes from an annular space about the big bell hopper, which reduces the average gas velocity and reduces the production of flue dust. These four offtakes lead to four uptakes, two of which are surmounted by Baer safety explosion valves. The uptakes lead into four downtakes, each two combining into one downcomer. The two downcomers enter the dust catcher radially.

The gas cleaning system is located between the boiler house and the blast furnace. It consists of one 22'x40' dust catcher for primary cleaning of gas. The gas is then led to a 12'6" Brassert tangential whirler where further amounts of fine flue dust are removed. From the whirler the gas is led through a series of goggle valve bypasses so arranged that the gas can be handled in a variety of ways. It is contemplated to run—and the system is thus arranged—so that all the gas is led through the Brassert gas washer, thence through a water seal separator to the main leading to the hot blast stoves and to the boilers. If desired, only the stove gas may be washed and gas sent from the whirler direct to the boilers, or in an emergency rough gas may be sent to both stoves and boilers. All these gas cleaning elements are located in one unit, completely equipped with platforms, thus making easy their supervision and care, and are standard equipment that have been used on upwards of 90 installations embodying well worked out means for obtaining gas with not to exceed 0.2 grains of dust per cu. ft. The washer is of the latest type of Brassert washer and has a novel arrangement of sprays which produces a large mass of spray having an intense whirling action. Not only is there an appreciable economy effected in the use of water, but the washer handles and cleans dirty gas even better than heretofore. To eliminate the nuisance of dust, which has always been such an annoyance at blast furnace plants when the dust catchers are dumped, Mr. D. T. Croxton has evolved an arrangement which will deliver the dust from the dust catcher and whirler to the cars in a moist state. This consists of a Bartlett-Snow double screw enclosed conveyor which is attached to the dust catcher by means of a special screening casting. The dust flows through this screen and falls into the first stage of the double screw conveyor. This conveys the dust down into an enclosed trough of water and delivers it to the second screw conveyor which again lifts the dust out of the enclosed trough and delivers it to the car. The dust in passing through the double screws submerged in the trough of water becomes thoroughly pugged and saturated with moisture. The coarse materials that do not pass the screen leading to the pug mill go to the bottom of the dust catcher where they are removed by occasional dumping of the main dust catcher bell. In an emergency the entire contents of the dust catcher may be removed in the usual way.

The gas main system consists in branches from the gas cleaning plant to both the stove and boiler gas mains. At both the stoves and boilers water seals are provided; in addition a further complement of water seals is installed so that the stoves or boilers may combinedly cut off from the entire gas cleaning system at cast or shut down, so that the wet cleaning system may be isolated from the dry cleaning system, and so that the entire system may be isolated from the furnace. These water seals are provided with large capacity lines so that water can be admitted and the seals filled in a very short time.

The blast main system starts at the turbo blowers. The discharge from the turbo blower is provided with an Ingersoll-Rand multiple port disc check valve. Motor operated cold blast valves are provided outside of the power house building. The cold blast main leads directly to the hot blast stoves, being provided with two counterweighted blast relief valves and the usual snort valve. The snort valve discharge is turned down into the stove flue. The by-pass leaves the cold blast main at its end and leads around No. 3 stove, entering the hot blast main at the extreme end from the furnace. It is provided with a McCarthy check and regulating valve.

The boiler house is 150 ft. long by 55 ft. wide and 43 ft. high. It is of brick and steel construction with corrugated steel monitor type roof. All window sash is of steel, Truscon type, glazed with factory rib glass.

There is provided 4,000 hp in units of 800 Class "M" Stirling four-pass boilers, built for 231-lb. pressure and 125 degrees superheat. All boilers are gas fired, being equipped with four improved 14" Birkholz-Terbeck burners. These burners are placed at the rear of the boiler under the mud drum, the mud drum being set at an elevation of 10 ft. to provide large distinct gas combustion chamber. The burners are provided with means for removal of cone for cleaning. Control of gas at the burners is by means of butterfly valves on the individual legs to each burner, and shut-off of gas is by means of one large gate valve in the main leading from the large boiler house gas main outside of the building. In addition this main can be filled with water to form a water seal valve, thus safely isolating any particular boiler when it is to be entered for cleaning or repairs. The boiler house gas main itself is outside of the building at yard level, and dust removed from the main is washed through a concrete trench direct to the sewer. The main has an auxiliary bleeder at its end as does also the stove gas main.

The boilers have provision for auxiliary coal firing, being equipped with Marion shaking grates. Coal is brought into the boiler house by means of a track hopper which discharges onto a Jeffrey belt conveyor. This conveyor was used in the construction work for handling brick and has been reinstalled at the boiler house to eliminate the large amount of hand labor usually employed in unloading coal. This Jeffrey belt in turn discharges to a Weller Manufacturing Company shuttle conveyor which runs along inside of the boiler house, by means of which coal can be discharged to any point along the boiler house floor. There are ash hoppers attached to the ash pits of each of the boilers. These hoppers are provided with gates at such elevation in the boiler house basement that a large truck can run beneath the hoppers. There is provided a concrete runway from yard elevation down into the basement floor of the boiler house, and ashes will be dumped direct from these hoppers into an auto truck and used for fill on the property.

The boiler draft requirements are furnished by a 225'x12'6" reinforced concrete stack built by the Heine Chimney Company, brick lined throughout. The boilers are connected to this stack by an insulated steel breeching. Other equipment in the boiler house consists of Williams feed water regulators and Babcock & Wilcox bare tube superheaters. The boilers are substantially built with particular reference to resisting gas explosions, and the front so constructed that by addition of a Dutch oven any standard type of stoker can be placed in the boilers in the event either of expansion of the plant or desire to generate additional electric power with the existing unit. The boilers are placed singly, right and left settings, 6' aisles.

The boiler feed water is normally taken from the service water mains of the blast furnace plant, it being delivered under standpipe pressure to the We-fu-go water treating system installed by Wm. B. Scaife & Sons Co. This is an intermittent cold process having a capacity of 20,000 gal. of water per hour. From the We-fu-go system a 500-gal. capacity pump, provided with a spare, pumps water to two Cochrane 4,000-hp open type feed water heaters. From the heater water is delivered to the boiler feed pumps. These are 4" four-stage double suction 500-gal. 600' head Worthington pumps, driven by Terry turbines. From the boiler feed pumps water is delivered to the boilers by means of an insulated boiler feed line. An auxiliary boiler feed line is also provided for emergencies. The two centrifugal boiler feed pumps are supplemented by a Worthington Duplex 500-gal. 300-lb. head reciprocating pump, which is connected up so that for normal operation it can furnish high pressure water for fire service, or at the top of the furnace, or around the blast furnace and cast house for flushing, cooling copper, etc. All these pumps are in the power house basement and one operating suffices to take care of the boilers.

The boiler house is laid out to permit expansion to the south for additional boilers, additional blast furnace units and coke ovens.

The power house, which is 154 ft. long by 60 ft. wide by 33 ft. from first floor, 18-ft. high basement, is also of brick and steel construction. Particular attention was paid to day lighting and ventilation. The blowing equipment consists of two Ingersoll-Rand turbo blowers. The air blower has five stages and the steam turbine seven. These blowers have a nominal capacity of 45,000 cu. ft. of air per minute at 30-lb. pressure, and will blow 55,000 cu. ft. of air per minute at 22-lb. pressure. The turbines are of new Ingersoll-Rand design, having but two steam admission valves, one for normal load and one for overload. The regulating device is also of an improved type, consisting of a single venturi instead of the old type of triple venturi. The single venturi is not so sensitively affected by leaks in the intake line, nor by dust or dirt in the air. There is a separate air intake for each blower which is led up to a considerable distance above the power house roof. Recording gauges are provided on each intake to record the amount and regularity of blast volume blown.

Electric power is generated in either of two Allis-Chalmers 1250 k. v. a., 80% p. f., 2300-volt, 3-phase, 60-cycle 3600 r. p. m. turbine generators equipped with direct connected exciters. A portion of this power is transmitted to the river pump house at which there are installed three 250-hp 2300-volt, 760 r. p. m. induction motions driving the centrifugal pumps. These motors are of the wound rotor type and are equipped with primary oil switches and secondary drum control, electrically interlocked. The motors were furnished by the Allis-Chalmers Manufacturing Company and the control switchboard was assembled by the engineers from parts furnished largely by the Westinghouse Electric & Manufacturing Co.

The bulk of the electrical power required at the plant is d. c. and to furnish this there were installed in the power house two Allis-Chalmers 750-kw, 720 r. p. m. motor generator units, supplying direct current at 250 volts. The driving units are 1160-hp 220-volt synchronous motors, excitation being taken from the d. c. units. The synchronous motors are started from auto transformers at 33% voltage in order to minimize the starting demand on the generator units. The power house switchboard contains 16 panels divided into an a. c. section of eight panels and a d. c. section of eight panels. The arrangement is such that future additions may readily be accommodated.

The a. c. switchboard is of the remote electrical control type. The oil switches are mounted in the rear of the board, liberal space being allowed for access. Of particular interest perhaps is the arrangement of a plug switch on each a. c. panel connecting with the power factor meter, thereby enabling the total power factor to be determined as well as the power factor of the individual generators, synchronous motors and feeders.

The d. c. feeders emanate from the power house direct to the car dumper and ore bridge and also to a distribution center at the blast furnace. Here the skip hoist, transfer car and scale cars, coke braize system, and cast house crane are fed. Another feeder terminates in a distribution center at the pig casting machine, from which the strand drives and ladle house crane are fed. The machine shop, office and power house auxiliaries are fed from the distributing panel of the power house switchboard. The greater portion of the electrical distribution is underground, liberal duct space being allowed for future growth of the entire system. The transmission to the river pump house was installed overhead for the reason that a portion of this line passes through territory subject to flooding. Duplicate feeder panels and feeders are supplied for this line to ensure continuity of service and to further protect the primary service pumps provision is made for connection to the Trumbull Steel Company across the river.

The lighting system for the plant is exceptionally complete and effective. A three-wire 115-230-volt system is installed. There are two transformers at the power house, one at the skip hoist and one at the pig casting machine. In case a transformer burns out, one of the units at the power house may be utilized for replacement and the lighting in the power house district temporarily reduced. Wherever necessary lamps are protected from moisture; all lamps have suitable reflectors and all inaccessible lamps have disconnected hangers. There is furthermore installed an auxiliary lighting system for emergency use, this being supplied from the exciter bus. The power and lighting installation is of exceedingly high type and safety for the men is provided in the shape of Leonard safety switches installed ahead of all starting and control equipment. Every detail has been arranged and installed in a most thorough manner.

Steam lines for the plant are in duplicate, consisting of a large main header having capacity for the entire steam demands of blower, generator, pumps and auxiliary machinery in the power house. This is supplemented by another header tied in at four points so that in the event of replacement of any fitting or gasket on the main header, a sufficient number of boilers can be tied to the power house, cast house and pig machine operation. This auxiliary line has sufficient capacity to run the blower and pumps with some reserve for partial load on the generator. The main steam lines are carried on brackets in the boiler house up to the tunnel which connects the power house and boiler house, where they are led direct to the power house. This same tunnel also serves for the boiler feed lines, high pressure water lines, service water lines and electric conduit, and is the regular means of communication between the power house and boiler house. All steam lines to blowers and turbines are underneath the main power house floor, thus presenting a very neat appearance. Steam lines and boiler feed lines are all covered with 85% magnesia insulation and have a very adequate equipment of drains and separators. The existing lines, inclusive of the main steam header in the boiler house with its lead to the power house, from the first element of the eventual power and boiler plant, when the header will expand into a complete loop system with additional cross connections between the power house and boiler house.

The power house is served by a Cleveland Crane & Engineering Co. 15-ton 4-motor crane, having 5-ton auxiliary hoist. Other equipment in the power house consists of a Worthington steam driven air compressor having capacity of 300 cu. ft. of free air per minute; the double Cochrane feed water heater; a 100-gal. Worthington reciprocating pump that pumps treated water to the offices for washroom and laboratory service; two 5″ 500-gal. motor driven water circulating pumps delivering water from the water treating system to the heaters; and a set of Richardson-Phenix continuous by-pass turbine oil filtering system units. All of the equipment in the power house excepting the turbo blowers, turbo generators, motor generator sets and the switchboard, are housed in the basement of the power house, where in addition are the three 10″ 4500-gal. 158-ft. head 1900 r. p. m. Worthington centrifugal pumps which pump the water for the plant use. These are driven by Terry turbines. The exhaust steam from the service pumps, from the boiler feed pumps, from the office water pump and from the compressor, all exhaust to the Cochrane feed water heater. In the basement are also the condensers for the turbo blowers and generators. There is provided at each blower an Ingersoll-Rand low level multiple jet condenser, and at each of the turbo generators there is a similar low level multiple jet condenser. These are installed for 28″ vacuum and due to the design of the condenser no air removal nor water removal pump is required. Both the turbine floor and auxiliary basement floor present a very neat appearance, there being ample room and entire absence of pipe interferences.

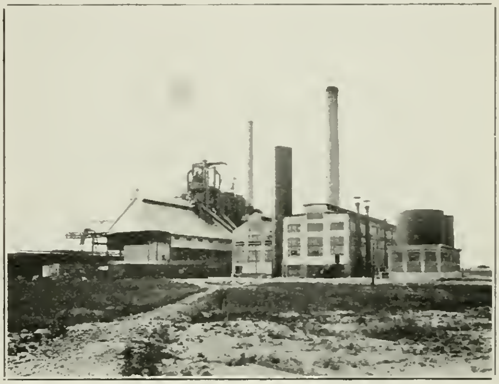

Fig. 13—General view of the plant.

The water system of the plant deserves particular mention as considerable economy is effected in the use of water, at the same time retaining the very desirable element of simplicity of circulation and furthermore obtaining the possibility of using different sources of water at many points in the event of failure of any particular source.

The water system starts in at the river pump house which is of novel design in that considerable space is saved, consequently eliminating considerable concrete and excavation work. The suction well for the pump is inside of the pump house, water being led from the pool outside into the tunnel though two 72″ link-belt vertical traveling refuse screens. These are fitted with ⅜″ screens and driven by 5-hp motors.

In the pump house are installed three 12″ 6,000-gal. 115-ft. head Worthington pumps, motor driven. Two of these pumps operating deliver water to the turbo blower and to the turbo generator condensers. Tail water from the condensers is led by means of a weir to a sump running lengthwise of the pump basement. From this sump the three 4,500-gal. Worthington service pumps, two operating draw their supply and pump through a 20′x120′ standpipe located between the power and boiler house.

This standpipe in turn delivers water to the blast furnace, cast house, hot blast stoves, cinder pit, gas washer, pig casting machine and water purifying plant, together with all other miscellaneous uses. The flexibility of this system may be appreciated by stating that the lines are so arranged that, if desired, the standpipe can be bypassed altogether or it can be used simply as a floater on the service line, no water being actually pumped through it. Safety provisions are adequately taken care of by connecting the line that leads from the river pumps to the condensers to the service water line into which the power house service pumps discharge. In the event of these pumps for any reason being out of commission, the river pumps have sufficient head to keep water on the blast furnace bosh, stoves, water seals and to supply water to the feed water treating plant, thus assuring a supply of water that will prevent damage or serious accident. A further safety provision is afforded in having this same by-pass line from the river pumps discharge, if desired, into the sump from which the basement service pumps draw their supply. This may be found useful in case the condensers have to be taken off. A further safety provision is found in an ingenious method of returning the bosh water. The overflow water from the furnace is all conserved and led by means of a separate pipe line back to a cistern at the extreme end of the basement sump. As long as the level of water in the basement sump is kept up to the mark by the water coming from the condenser tail water pits, then the return water from the furnace overflows into the sewer and back into the river. However, if the amount of water coming through the condensers and thence to the sump should for any reason be deficient, then the return water from the blast funace runs into the sump from which the service pumps pull their supply. Under normal conditions of operation there is about a 40% surplus of condenser tail water going into the sump over and above the amount of water required at the plant exclusive of condensers. To still further safeguard the plant supply of water the lines of the standpipe are equipped with check valves which will prevent the standpipe from emptying in the event of a break in the line. A final safeguard at the furnace is found in the provision of check valves in the two distinct water supply lines leading to the circle pipe. Between the circle pipe and these check valves is connected a line from the Worthington high pressure pump and inasmuch as this is in normal operation continually kept floating on the high pressure line, then in the event of failure of lines or service pumps the furnace bronze can be preserved by opening up the line admitting high pressure water to the circle pipe, the check valve preventing escape of this water back into the main service water line. This high pressure water is similarly piped up to the stove fittings and to the main isolating water seal valve, and in an emergency the high pressure pump can draw its supply of water from the standpipe which, in the event of a very bad accident or breakdown at the pumps or lines, would still remain full of water. It will be seen that the plant is assured of a supply of water that will last almost indefinitely in an emergency by virtue of the provisions for recirculation of water.

The boiler feed pumps similarly have a triple source of supply. Normally they take from the feed water heater. In emergency they also draw from the basement sump, from the blast furnace service water lines or from the line leading from the river pumps to the condensers. The turbines similarly draw on two sources for their supply of cooling water, i. e., the service water supply line and the condenser water supply line.

In addition to the link belt traveling screens at the river pump house, the lines are further provided with Elliott twin basket strainers at both of the supply lines to the furnace circular pipe and to the stoves, and also at the line leading to the gas washer. The boiler feed line, the gas washer line and the furnace supply water line are provided with venturi meters.

A tank is provided at the machine shop to which treated water is pumped from the power house basement for the use of the yard locomotives.

The sewerage system is very largely an open one, this type being decided upon on account of the many unfortunate experiences with closed sewers about blast furnace plants where so much rubbish, such as graphite, granulated cinder, etc., is liable to plug the sewers. Special pains are taken at the cinder pit to avoid escape of granulated slag into the sewer system, there being provided a settling basin and submerged weir to prevent as much as possible the escape of cinder. The overflow water from the pit runs through a screened open sewer to the sump beneath the gas washer. Here the cinder pit water joins the discharge from the gas washer and is led in an open sewer to the boiler house. A sewer, which carries off ash-up water and also the drainage water from the hot blast valve fittings is led from the furnace and stove foundations to intercept the main open sewer. At this point the sewer runs underground a distance of about 500 ft. through 48" reinforced concrete sewer furnished by the Massey Concrete Products Corporations. The boiler house and the trench underneath the gas main in the rear of the boiler house are drained into this sewer. As it passes beyond the corner of the power house it emerges again into an open sewer which is led down to the river. Into this sewer also drains the surplus condenser water; any surplus bosh return water, and the drainage from the power house basement. The sewer is of ample capacity to handle all surplus and waste water as well as storm water about the plant.

Hot metal is normally shipped to the mixer of the Trumbull Steel Company, but there is also provided for the casting of chill iron a double strand pig casting machine. This is standard Heyl & Patterson equipment having manganese links and pins. The pig machine strands are mounted on a reinforced concrete structure. This type of construction was oiginated at the blast furnace plant of the Otis Steel Company and was chosen because of elimination of deterioration encountered with structural steel supports by reason of the large amounts of steam and water about the operation. The concrete structure provides a continuous platform under the strands, makes for an easy replacement of molds, and provides a channel for spray water which is carried into a sump at the pouring end. The length of rails is limited to 11 ft. to make a convenient length for handling when replacements are necessary. All castings used in connection with the machine and in connection with the structure can be replaced with open sand castings poured at the cast house of the plant. The machine is laid out for additional strands with the growth of the plant. Integral with the pig casting machine is a combined ladle and pouring house. In this is a 55-ton Morgan pouring and ladle handling crane having 100% overload capacity. This serves both to pour the ladles by means of the patented Pollock short pour device and also serves for removing the ladles from the trucks for relining. A spare ladle is provided to be held in reserve for lining.

Considerable study was given the location of the track scales and these were so located that they serve admirably both for the light and heavy weighing of pig iron cars as well as for check weights on receipt of raw material into the yard. A well designed scale house is noteworthy, in which is also incorporated the yardmaster's office, locker rooms for train crews and washroom facilities. The facilities at the scale house office are supplemented by a larger locker and service room for the furnace men located in proximity to the incline leading from yard level up to the furnace and stove foundation top. Additional toilet and locker rooms are located in the basement of the power house and boiler house for the men, and at the machine shop.

Provisions for repair and maintenace of the plant and its equipment are all grouped in one large central machine shop building. In the center bay of this building is the machine shop proper which is arranged for a traveling crane spanning a very complete complement of machine tools adequate to machine and repair all parts of equipment and castings going into the construction or repair of the plant. There are two lean-tos which house the chief engineer's and general master mechanic's office, and which also have the pattern shop, electrical shop, pipe fitting shop, blacksmith shop and storeroom. The storeroom for large castings and bronze parts is in a bricked-in house under the trestle approach and the storage for rigger tools is in a similar brick house. The general administrative and executive offices are in a large well designed building at the plant entrance. Here is placed the general superintendent's and his assistant's office, the office of the chief clerk and the timekeeping, distributing and clerical force, the laboratory, police and employment offices, and the cafeteria.

The quantities of material used in connection with this job are of interest. There were placed 2,246 20′ to 30′ Raymond reinforced concrete piles; a total of 61,974 cu. yd. of excavation; 31,601 cu. yd. of concrete; 224,365 cu. yd. of fill; 750 tons of reinforcing steel; 1,270 tons of plate; 729 tons of castings; 145 tons of structural shapes; 65 tons of forgings; 1,251 tons of structural steel in buildings 1,020 M building brick; 2,083 M fire brick, and an average of 371 men were employed per day for the 10 months' period of construction.

The contractors engaged in this work were as follows: Fabrication and erection of iron and steel work other than structural, the William B. Pollock Company; fabrication and erection of structural steel in buildings and skip incline, Lackawanna Bridge Company and Hill Clutch Company; Phenix Iron Works and the Pennsylvania Engineering Works furnished some of the iron and steel castings. All brick work in furnace, stoves, boilers, power house and offices was placed with the P. J. Brown Construction Company; the concrete was put in by Arthur G. McKee & Co.; car dumper and ore bridge, Mead-Morrison Manufacturing Company; ore bins and scale cars, Hoover & Mason. Piping was installed by B. Floersheim & Co. Instruments for the blast furnace and power and boiler houses were supplied by The Bristol Company. The Trumbull-Cliffs Furnace Company, in the person of Mr. J. S. Fraser, works manager, and Mr. O. C. Callow, electrician, supervised and directed the placing of most of the equipment wiring and switchboard.

The construction of the plant was directed by the organization of the Cleveland-Cliffs Iron Company through Mr. D. T. Croxton, manager of their pig iron sales department. The plans and specifications for the complete plant and plant equipment were drawn up by Freyn, Brassert & Co., Chicago. These engineers also had supervision of construction, Mr. Roy W. Clark being chief resident engineer, for the firm.

The Trumbull-Cliffs Furnace Company, through its executive and its superintendent, coöperated with the engineers in all details of planning the work, in purchase and delivery of materials, and in expediting the work in the field.

On completion the Trumbull-Cliffs Furnace Company held "open house" and the plant was visited by a large number of executive and operating officials of the iron and steel plants of the country. The many features and the remarkably quick time of construction have been the object of much favorable comment and the Trumbull-Cliffs Furnace Company is not only to be commended for the opportunity it has given the men in the industry for personal inspection of the plant, but is also to be congratulated upon the ownership of a plant that represents such a conservative and successful application of sound operating and engineering features.

QUESTIONS AND ANSWERS.

Question recently submitted to the Blast Furnace and Steel Plant.

"What is the cause of negative brushes pitting and the positive brushes picking copper on a D. C. generator 800 kw. 83 rpm. 3,200 amps? Machine is not overloaded.

Answer: The condition experienced above is in the nature of an electralytic action. Where the electric current flows from one surface to another, there is a tendency for small particles from the substance out of which the current flows to the other conductor.

Thus in a generator, negative brushes are eaten away and the carbon in some cases deposited on the surface of the commutator causing it to blacken.

If the action is more severe, copper is taken away from the commutator and deposited on the positive brush, and the commutator takes on a bright surface but does not polish.

This action is due to too high current density under the brush. This may not necessarily mean that the load current is too high, but rather that the short circuit current—due to improper commutation of the voltages generated by the process of commutation is excessive.

This may be caused by improper brushes, wrong and gap between armature and interpole, saturation of the interpole circuit, interpoles not properly adjusted as to the ampere turns, and brushes not on the electrical neutral.

This action will also be noted on revolving field alternators, where one ring becomes very rough and is eaten away while the other ring takes on a bright polish.

This action also comes into play on the slip rings of rotary converters, causing them to become eccentric and the brushes to chatter.

This explains why brushes should be staggered in pairs and not alternately. In staggering brushes alternatively the positive brushes will run in the same track, thus grooving the commutator.

A large majority of comutator wear is due to this and not to the abrasive material in the brushes as often supposed.

Steel Plant Electrical Engineers Convention

Association of Iron and Steel Electrical Engineers Hold Fifteenth Annual Convention in Chicago—Many Valuable Technical Papers Are Presented—Interesting Exhibit of Electrical Equipment for Steel Plants.

THE Fifteenth Annual Convention of the Association of Iron and Steel Electrical Engineers was held in Chicago, September 19th to the 24th. The headquarters being at the LaSalle Hotel and the sessions and exhibits on the Municipal Pier. About one thousand members of the Association attended the Convention.

Technical papers were presented by well known men of the steel industry, among whom were:

R. B. Gerhardt, Electrical Superintendent,
Bethlehem Steel Company, Sparrows Point, Md.
R. D. Cousins, Electrical Engineer,
Illinois Steel Company, Gary, Indiana.
G. R. McDermott, Assistant Engineer,
Illinois Steel Company, So. Chicago, Ill.
W. N. Flanagan, Steam Engineer,
Ohio Works, Carnegie Steel Company, Youngstown, Ohio.
F. B. Crosby, Electrical Engineer,
Morgan Construction Company, Worcester, Mass.
A. C. Bunker, Electrical Engineer,
Crocker Wheeler Company, Ampere, N. J.
A. M. MacCutcheon, Designing Engineer,
Reliance Electric & Engineering Co., Cleveland, Ohio.
E. T. Moore, Electrical Engineer,
Halcomb Steel Company, Syracuse, N. Y.
F. W. Cramer, Engineer of Tests,
Cambria Steel Company, Johnstown, Pa.

Abstracts of several of these papers are given in this issue of "The Blast Furnace and Steel Plant" magazine.

The exhibits were very interesting. Practically all the large electrical manufacturing firms were represented. The social end of the Convention was very well taken care of.

One particularly interesting paper was presented by F. B. Crosby on "The Electrical Engineer in the Steel Plant and Out." During the course of his paper Mr. Crosby said:

We are so often reminded that "This Is an Age of Specialization," it may be hardly necessary to again emphasize the fact that never in the world's history has the demand been as insistent as it is today for men skilled to a degree possible only to the intensively trained specialist. This demand is not a passing fad or fancy, but is rather the direct result of necessity.

In all ages there have been those who, by virtue of unusual talents, inherited or acquired, have stood head and shoulders above their fellow workers. It is probable that even in those far distant days when man first began to exercise the power of reason, and thus began his never ending divergence from the lower forms of life, it was noted that certain individuals of the tribe could more effectively fashion clubs, hatchets and arrow heads, while others were more proficient in the use of these crude implements of warfare and the chase.

The maker of arrow heads did not possess, nor did he have the ability to acquire, the skill of his brother in the chase. He remained, therefore, in his cave busy at his own craft producing a supply of arrow heads to exchange for a portion of the necessities and luxuries of existence accumulated by his more strenuous brother.

What is more natural, then, than that there should have come into existence, even in the early dawn of human progress a partial segregation of labor and a system of barter which, in its essentials, bore the same relations to the average intelligence and needs of the individual as do our great productive enterprises to the keener intelligence and more comprehensive requirements of today.

As the race merged from a state of savagery its wants became increasingly diversified and the maker of stone arrow heads became the maker of implements of wood and bronze. The variety of products demanded of him became so great that he could no longer construct all with equal facility, consequently he quite naturally devoted his attention chiefly to those articles which he could produce better and quicker than his neighbor, and thus assure to himself a profit from his labor. So we have another step in the segregation of industrial activities as a logical sequence of the progress of mankind.

Our primitive ancestors recognized, with reason scarcely to be differentiated from instinct, certain fundamental economic principles which we with all our boasted advantages of civilization are too apt to disregard or completely lose sight of.

The comparatively early appearance of the religious motive inherently characteristic of all mankind gave rise to a priesthood which for many centuries seems to have developed and concentrated within its own jurisdiction all existing knowledge of metaphysics, engineering and what is now referred to as "pure science." The ancient Aztecs and Egyptians must have possessed a knowledge of mathematics and astronomy almost unbelievable, in view of their apparent lack of our modern aids in this field of research. The Aztec calendar, carved in stone and still in existence, provided at least 50 per cent greater accuracy in the measurement of solar time than does the Gregorian Calendar

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Included in the report of this meeting are abstracts of several of the papers read. Complete papers may be secured from J. H. Kelly, Secretary, Association Iron and Steel Electrical Engineers, Pittsburgh, Pa.

produced many centuries later, and now in general use throughout the civilized world.

Such marvelous achievements as the Egyptian pyramids, the hanging gardens of Babylon, the unsurpassed architectural features of the stone temples in the Peruvian Andes and of the Aztecs in ancient Mexico, are silent but commanding witnesses to the master minds which conceived them and directed their construction. Who can say but that these ancient works will continue to stand for untold centuries after the greatest of our modern engineering enterprises return to dust and the great nations of the present times are but a fading memory?

In reviewing the work of past generations, one always finds the specialist. He has ever been an essential factor in the intellectual and aesthetic as well as the industrial life of all peoples. His functions have been identical in character and have changed only in degree. Every age has had its great artists, sculptors, writers, philosophers, executives and skilled craftsmen. Many of these have been great not only when measured by standards of their own day and environment, but by the standards of all time.

With the introduction of the age of steam and electricity came unprecedented improvements in transportation. With almost unlimited facilities for personal communication and interchange of ideas through the media of telegraph, telephone and modern press, the sum total of human knowledge has increased more rapidly than has the mental capacity of the individual for assimilation of this knowledge.

The average level of human experience and knowledge is rapidly rising, and at an increasing rate. The inability of the finite mind to grasp the infinite or even that infinitesimal portion represented by classified knowledge has compelled an attention to detail on the part of the present-day business or professional man which, in too many instances practically precludes more than a superficial acquaintance with other equally essential activities.

And so we find a logical basis for our major premise; that today is the day of the spcialist whether it be in politics or business, in the field or art and letters or in the professions of law, religion, medicine or engineering.

The day of the Jack-of-all-Trades, an extremely valuable member of society in pioneer life, is rapidly giving way to the man whose motto is "To know everything about some thing and something about everything."

This condition of affairs is by no means an unqualified blessing; in fact it possesses certain very undesirable not to say dangerous possibilities.

The electrical engineer is a much younger but very lusty offshoot of that fraternity so long composed chiefly of mechanical, civil and mining engineers. It is but forty years since the Edison bi-polar of 16 incandescent lamp capacity represented the climax of electrical achievements, yet in that short time the electrical industry has grown to the marvelous proportions with which you are familiar.

We have long since reached the point where to be known as an electrical engineer is not sufficiently distinctive. In no other of the several main branches of engineering has the necessary and continuous subdivision of duties been so marked. A general knowledge of the fundamental laws of electricity and magnetism is essential in all cases, but today we must have the specially trained electrical expert; one, for example, who shall concentrate all his efforts on the design of motors, and not merely motors, but alternating current motors, and still further a specific type of alternating current motor; another on certain types of generators; another on transformers; another on switchboards; another on magnetic control; another on station layout; another on transmission systems; another on application and operation of all these. We must, also, have the telephone engineer, the signal engineer, the illuminating engineer, the electrochemical engineer, and so on without end—and yet they are all electrical engineers; each in the daily routine of his highly specialized effort is absolutely dependent upon the separate and combined efforts of all the rest.

This interdependence and necessity of close cooperation must be emphasized. Any attitude of jealous exclusiveness within engineering bodies which should and do have so great a community of interests as do the American Institute and the A. I. & S. E. E. is greatly to be deplored. The functions of these two associations make contact at many points and in some instances overlap, but as a whole they certainly are not super-imposed. The A. I. E. E. has the greater range of interests and is the inclusive organization. All of our members should be, as many of them already are, members of the A. I. E. E. also. We must regard ourselves as a part of the great body of electrical engineers, and at the same time as a group of specialists who for the advancement of our individual and collective interests as steel mill engineers must maintain our organization as an independent entity.

With the increasing variety and complexity of electrical interests, the line of cleavage between the so-called operating engineer and the engineer who confines himself to research or design threatens to become even more sharply defined and, while this to a certain extent is inevitable, it is most unfortunate. We must each exert himself to overcome this natural tendency and endeavor to become familiar with others' problems at least to the extent of yielding intelligent appreciation of their efforts.

As operating engineers we cannot escape the fact that we are deeply indebted to those of our profession who spend their time and energy in experimental and analytical investigation of such natural resources and phenomena as have not yet been brought to a state of practical utility. The man who by virtue of natural ability and opportunity gives himself to research and the classification of theories will naturally tend to foregather with those of similar interests. This is equally true of the man who, lacking the opportunity for intensive training in a technical institution, has been forced to accumulate his experience first-hand from direct contact with problems of installation and operation. There are extremes of each of these types who can never speak a common language, but the great majority of us in whatsoever manner our experience may have been gained, will be mutually benefited by closer association and interchange of ideas. We must avoid the danger of "inbreeding" which is just as real in engineering as in agricultural pursuits. Professional jealousy or indifference and its resulting insularity of ideas is more often than otherwise a confession of weakness. On the other hand competition and professional rivalry are most desirable and should be encouraged.

We have heard much in recent months of the need of "Less Government in Business and More Business in Government." We should go further. We need "More Engineering in Government, Both Local and National."

We need the same kind of reasoning and the same type of administrative methods in our civic affairs that we find in force in any of our great engineering works. The trained engineer compelled to look facts squarely in the face, who deals daily with the unchanging characteristics of material substances, and the laws which govern the transformation and dissipation of energy, comes to consider orderliness and the elimination of waste whether of effort or materials, as the greatest of human objectives. His one aim in life is to bring the margin between actual achievement and 100 per cent efficiency to an irreducible minimum.

The engineer is coming into his own at last largely because of a clearer recognition and personal acceptance of the part which his training and experience peculiarly fit him to play in moulding public opinion and directing public affairs.

Engineering has been defined as "the art of utilizing the materials and controlling the forces of nature for the benefit of mankind." This definition falls short of its intended scope fi it does not include among the available "material and forces of nature," the personalities and mental equipment of our fellow men. In these days of industrial and social unrest we need as never before the clear vision and straightforward reasoning of the engineering mind with its power of discrimination between fact and fancy, and its logical deduction therefrom unbiased by sentiment or emotion. As engineers and as citizens we must face and accept the responsibilities which are inseparable from the privileges of education and experience which this country affords. It is up to us as individuals and as an organized body in the interests of society, which includes equally, ourselves, those for whom we work, and those who work under our direction—to exert ourselves to counteract the unsound propaganda put forth by unscrupulous or at best uninformed leaders of organized labor. Unfortunately the danger to our social and industrial life from this source is scarcely greater than from the emotionalism of many of our self-appointed modern reformers who through the media of the lecture platform, pulpit and press are vigorously attacking with sweeping condemnation the whole industrial system. The danger from this source lies not so much in the evils revealed as in the misrepresentation of facts through carlessness or by malicious intent and the erroneous deductions therefrom. The total absence of constructive criticism on the part of these would-be reformers cannot fail to leave in the minds of the average person who rarely takes the troubles to ascertain the facts and form unbiased opinions, an impression of unrest, discontent and hopelessness entirely unjustified by actual conditions.

Anti-Friction Bearings in the Steel Mill

By A. M. MacCUTCHEON.

THE history of the anti-friction bearing is closely identified with the development of the bicycle and the automobile. Elimination of friction has always been a most fascinating study in all branches of engineering. There is no authentic record of the date at which it was found that rolling friction was less than sliding friction, but presume it was at that time when our forefathers found it easier to roll than to drag a body. The use of rollers under a block of stone was known to the ancient Egyptians. Wheels used on chariots marked the first development in changing rolling friction betwen the ground and the weight, to rubbing friction in an axle. Later it was found that if the surface in the hub where the friction took place were properly prepared and lubricated, a great reduction in friction resulted. Bearing development has generally been in the direction of reducing friction and increasing reliability. Crude ball bearings were first considered about 1862 to 1870, the Patent Office files showing several patent applications at about this date. These early ball bearings, however, were not practical and are merely of theoretical interest. The first practical applications came in the early nineties with the use of the cup and cone bearings on bicycles. The tremendous development of this industry furnished the stimulus for a very intensive effort toward the production of a bearing which could be more general in its application. The first type of the annular or ring ball bearing was developed about 1901, based upon investigation made by Professor Strybeck. The annular bearing consists of two entirely independent concentric rings of practically rectangular section and with groove shaped raceways in the outer surface of the inner ring, and the inner surface of the outer ring. In this groove a row of balls is placed and the whole is a self-contained, non-adjusting bearing. It was recognized that theoretically the annular bearing should contain as many balls as the space permitted. The number of balls which may be introduced in any bearing is very intimately connected with the method of assembly, which will be discussed in greater detail under the various types of bearings. One method is to have a slot in the side of the bearing which method permits of the maximum number of balls, but which results in a break in the continuity of the race and usually seems to necessitate the use of a shallower groove.

Another method is embodied in the Conrad patent, in which the introduction of the balls takes place by means of an eccentric displacement of the rings in relation to each other.

With this method the number of balls which may be introduced is limited, the raceway, however, is continuous and very deep grooves may be used. At

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Abstract of Iron and Steel Electrical Engineers Convention paper.

about this time a large number of ball and roller bearings were designed and built, some of which proved to be very satisfactory, and some quite the contrary. Little was known as to the proper selection of the size of balls, and many misapplications were made. Some of the engineers working on the anti-friction bearing problems felt rollers would be more desirable than balls for use in a bearing, claiming that with a roller line contact is secured as opposed to point contact in a ball bearing. This claim, however, is not conceded by the manufacturer of ball bearings. One particular type of bearing which has been very largely used was developed with a roll not solid but made up of a spiral. Considerable difficulty was experienced with misalignment, and the consequent stresses not anticipated in the design. In 1906, a native of Sweden invented a two row annular bearing with a self-aligning feature, which it was claimed eliminated the sensitiveness to misalignment. Another claim for the double row bearing is the increased number of balls which may be introduced in such a bearing. In 1905 the first commercial application of annular ball bearings was made in America, although these bearings had been previously used in some of the foreign countries. The application was on a marble polishing machine for the Empire City Iron Works in Long Island, and the application proved quite satisfactory. At about the same time the first application of ball bearings was made on electric motors. It is at least interesting to note that the two electrical manufacturing companies who were the pioneers in the use of ball bearings for motors are still using such bearings, and consider them entirely satisfactory. In 1905, ball bearings were being favorably considered by the automobile industry, and during that year they were applied to the transmission of a 50 Hp Thomas Flyer. In 1906, an Apperson built for the Vanderbilt Cup Race had its transmission so equipped. In 1910, one of the machine tool companies exhibited at Atlantic City and elswhere a vertical spindle drill press mounted on ball bearings, which drove an inch and a half drill through 31 inches of cast iron per minute, and a three and a half inch drill through 11½ inches of metal per minute. This of course meant a very heavy end thrust on the bearings. Also in 1910 ball bearings were used to take the thrust on belted vertical milling machines. It is interesting to know that ball bearings have been used on power punch presses where there is undoubtedly a very heavy shock condition. The claim is made that on such a press the use of anti-friction bearings decreased the idle stroke power 54 per cent and the working stroke power 20 per cent, and that the power saving for the complete cycle was 40 per cent. 1910 marked another interesting application of anti-friction bearings to a cold saw which ran at 4100 rpm. The use of plain bearings had required renewal of the bearing about once in three weeks with the consequent shutting down of the machine. Twenty hp was required to drive the saw when equipped with oil type bearings, and water cooling was employed. After the change in the bearings a 7½ hp motor was substituted for the 20 hp, and there is no evidence that further bearing trouble occurred on the machine. Since that time anti-friction bearings have become extensively used in the automobile, aeroplanes, lathes, grinders, planers, drill presses, textile machinery, woodworking machinery, pulp and paper machinery, grain milling machinery, farm tractors, pumps, printing presses, portable tools, ventilating fans, shaft hangers, electric motors and on many other machines. The early days of anti-friction bearing application saw many failures,

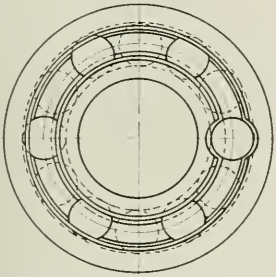

Fig. 1—Assembly of Balls.

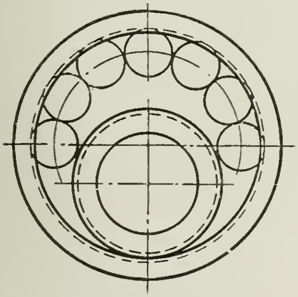

Fig. 2—Assembly of Balls.

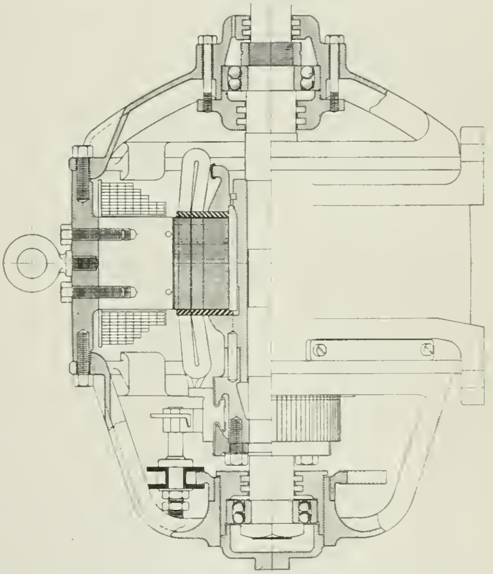

Fig. 3—Ball Bearing Mounting.

possibly due to lack of knowledge and the consequent misapplication. It is undoubtedly true that the anti-friction bearings being manufactured today are vastly superior to those manufactured 10 or 15 years ago.

In no other line of manufacture has there been a greater attempt at standardization and many of the bearings of different manufacturers are absolutely interchangeable. Careful consideration of the history of the anti-friction bearing industry would seem to indicate that this type of bearing certainly merits a careful study by any industry. Requests for information were therefore forwarded to the various ball bearing manufacturers, the railway electrical engineers, machine tool builders, the motor manufacturers and such of the steel mills as were known to have done some experimental work relative to the use of anti-friction bearings. Their experience is discussed more fully later in the paper.

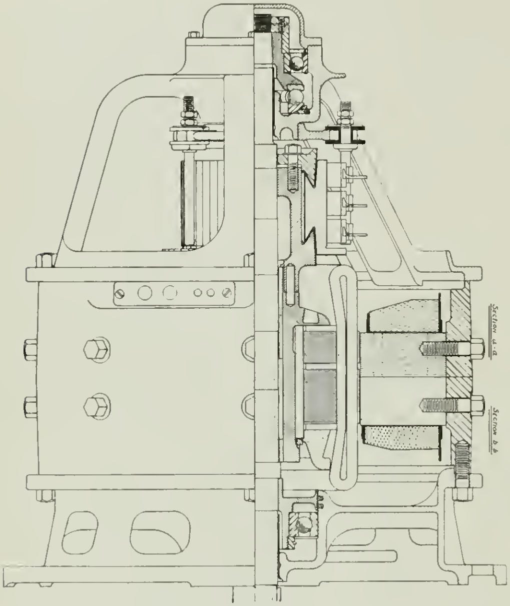

Fig. 4—Vertical Ball Bearing Mounting.

It is interesting to note that the catalog published by one of the anti-friction manufacturers lists a bearing ½-inch outside diameter and which weighs scarcely more than a few ounces, while the largest is over 19 inches in outside diameter and weighs approximately 300 pounds. Special large radial bearings have been made by this company, having an outside diameter of 32¼ inches and a bore of 15¾ inches. This bearing is fitted with 34 balls 4¼ inches in diameter and has a total weight of 1,000 pounds. The bearing will carry a weight of 80 tons at 100 rpm.

Today many types of anti-friction bearings are being manufactured, to some of which reference has already been made. A classification with examples of each type will undoubtedly be of interest. No type or manufacturer has intentionally been omitted, but the information is not complete.

1. Ball Bearings

(a) Annular Type with Deep Grooves Ball Assembled by Eccentric Displacement of the Races.

The Hess Bright Ball Bearing Company.
The Fafnir Ball Bearing Company.

(b) Annular Type with Balls Assembled through Filling Slots Permitting of a Large Number of Balls.

Ball bearings manufactured by the Standard Roller Bearing Company.

(c) Annular Type with Balls Assembled by Expansion of the Outer Race under Heat, permitting of a large number of balls.

The Gurney Ball Bearing Company.

(d) Annular Type with a Double Row of Balls Permitting of a Larger Number of Balls.

The New Departure Ball Bearing Company.

(e) Annular Type with a Double Row of Balls and Self-Aligning Features.

S K F Ball Bearing Company.

2. Roller Bearings

(a) Self-contained with the Inner and Outer Races forming a cage for the Rolls. Rolls assembled through filling grove.

The Rollway Roller Bearing Company.

(b) Semi-flexible Spiral Roll assembled between End Cages and with the Outer and Inner Race slipped over and within the Rolls, permitting of easy disassembly, but not capable of taking end thrust.

The Hyatt Roller Bearing Company.

(c) Tapered Rolls assembled between End Cages and with Tapered Races, permitting of easy disassembly, taking end thrust, and making possible adjustment for wear.

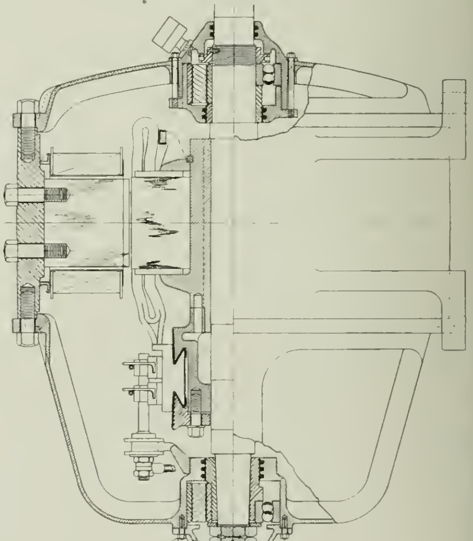

Fig. 5—Ball and Roller Bearing Mounting.

The Timken Roller Bearing Company.

Practically all types of ball and roller bearings are assembled with end cages which maintain the proper relation in position of the ball and rolls. The proper design of these end cages is as necessary as the proper design of the rest of the bearing.

Manufacture.

The manufacture of anti-friction bearing is a highly specialized industry requiring special machinery, special materials and special operation. All bearings must be subjected to exceedingly rigid inspection and test. The three most important properties which a finished anti-friction bearing should possess are (1) High fatigue limit and strength. (2) High resistance to shock. (3) Highest possible resistance to wear. Each bar of steel used in the manufacture of balls or rolls and races is tested. The steel must possess in the highest degree the qualities of hardness, toughness, durability after hardening and resistance to shock. The best grade of balls are made of chrome alloy steel and carefully heat treated. They are hardened clear through which makes the steel tough and less liable to crack under excessive load. The balls must be as spherical as it is possible to make them. The best grade balls are ground to size within one ten thousandth of an inch. This accuracy is necessary to secure uniformity in the size of the balls and the consequent even distribution of the load. The manufacture of a ball involves eleven main operations as follows:

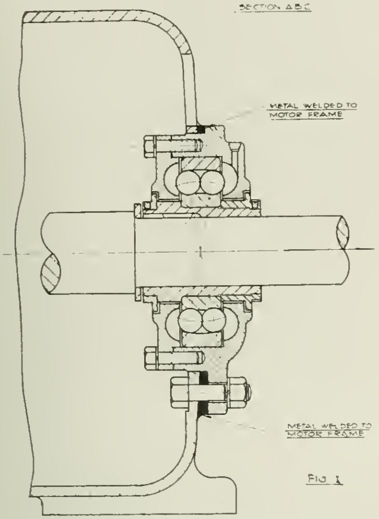

Fig. 6—Ball Bearing Mounting, Mill Type Motor.

1. Inspection and testing of steel stock.
2. Forging or pressing in dies into rough spheres.
3. Annealing to eliminate internal strain.
4. Rough grinding.
5. Second heat treatment. The balls are hardened and then drawn to toughen the steel.
6. Second rough grinding to a fairly smooth surface and more accurate spherically but still considerably oversize.
7. Precision grinding with fine grade wheels and heavy oil holding an abrasive in suspension.
8. Final grinding in Hoffman machine, in which the balls are ground to within a small fraction of the finished size.
9. Polishing balls in a tumbling barrel.
10. Burnishing the balls by which the surface is polished to a mirror finish.
11. Final inspection and test for hardness, sphericity and size.

The balls are gaged with special machines calibrated with special care and by the use of an instrument with which it is possible to determine the size of the steel ball to an accuracy of within .00005. The same care is exercised in the manufacture of the races. One of the bearing manufacturers advises that it is necessary to manufacture their own steel because of the exacting specifications. The steel tubes of which the races are manufactured are formed by forcing through the entire length of a steel bar a pointed steel tool, which results in a tube free of welds, laps or seams and which has a uniform strength and texture on its entire circumference. The tubes are finally cold drawn to a size within a very close limit. This brief summary of manufacture has been given in the belief that a general understanding of the care exercised in the manufacture of anti-friction bearings will result in a more intelligent consideration of their use.

Selection of Anti-Friction Bearings.

Experience has demonstrated that many failures have resulted from the improper selection of the size of bearing to be used, for a particular application. If anti-friction bearings are applied to motors, close cooperation is essential between the motor manufacturer and the ball bearing manufacturer. About four years ago the writer of this paper discussed with an electrical engineer of a well-known eastern railroad the success which they had experienced with ball bearings on car lighting generators. The advice of this engineer was to select a bearing two sizes larger than indicated by a consideration of the load which the bearing was expected to carry, and the load which the bearing was guaranteed to carry. He attributed the entire absence of trouble on car lighting outfits to the following of this plan. In justice to the manufacturer of the anti-friction bearing, it should be stated that since that time

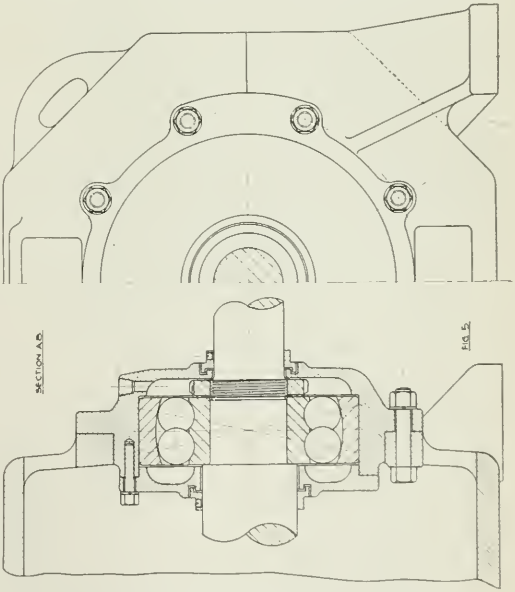

Fig. 7—Ball Bearing Mounting, Mill Type Motor.

a very exhaustive study has been made of the requirements of anti-friction bearings applied to motors so that they are in a far better position today than they were at that time to specify the safe working load for the bearing. From many sources information has been received that if the bearing is selected large enough and properly applied, no failure will ever result. This undoubtedly is an extreme view but is interesting as evidence of the confidence which some users of anti-friction bearings have in this type.

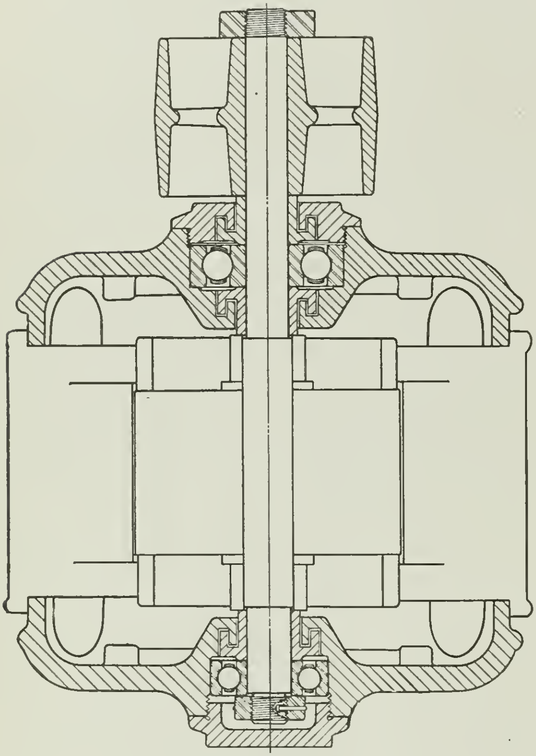

Fig. 8—Ball Bearing Mounting, Labyrinth Grooves.

Mounting of Anti-Friction Bearings.

In succesfully designing a mounting of an anti-friction bearing motor, the following points must be kept in mind:

a. Ease of assembly. It should be possible to draw the bearing off the shaft without transmitting pressure from the outer race to the inner race through the ball. It should be possible to remove the armature without the removal of the bearing from the shaft.

b. The bearing should be protected against the entrance of dirt or grit. If such foreign substances are present within the bearing, the life of the bearing will be very short.

c. The lubricant must be retained within the bearing housing.

d. The bearing must be the proper fit on the shaft and within the housing.

e. The inner race of bearing must be locked in place against a suitable shoulder by a suitable locking nut.

Illustration 3 represents a typical mounting on a general service direct current motor. Attention is drawn to the mounting at the commutator end where the bearing is entirely enclosed in a cartridge which is removed from the motor with the armature. It is believed that such enclosure is the most satisfactory form of mounting but is somewhat more expensive. It is evident that the armature may be entirely removed from the motor without disturbing the fit of the ball bearing on the shaft. A suitable mounting is always difficult at the commutator end of a direct current motor of the general service type since the outer dimensions of the bearing housing are limited by the position of the rocker.

Figure 4 is a typical mounting of a vertical general service motor in which the weight of an armature is carried by a thrust ball bearing at the top.

Figure 5 is a composite mounting showing the application of a ball or roller bearing to the same general service motor.

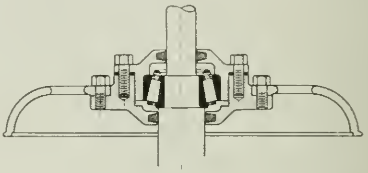

Fig. 9—Roller Bearing Mounting, Enclosed.

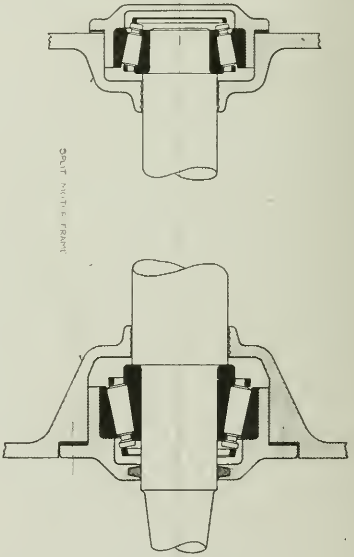

Fig. 10—Roller Bearing Mounting.

Figure 6 is an application of a ball bearing to a mill type motor. The bearing is completely enclosed in a cartridge which is removed from the motor with the armature, effectively excluding foreign substances. This application was laid out in connection with changing over oil type motors to anti-friction type. The ball bearing is mounted on a sleeve which is driven by a Woodruff key. The sleeve has the advantage of a long bearing on the shaft and may be required in very heavy service. In general it is not felt that it is necessary. Certainly not on general service motors.

Figure 7 represents the mounting of a ball bearing in a steel mill motor with the bearing carried directly on the shaft and without the cartridge enclosing the bearing. Unusually complete protection is provided against the escape of grease by what may be described as the "labyrinth" type of groove. Nearly all types of anti-friction bearings will take a very considerable end thrust; from 30 to 40 per cent of the radial capacity of the bearing up to 100 per cent or over. It is, therefore, not necessary to provide any other device to take the end thrust ordinarily found in motors.

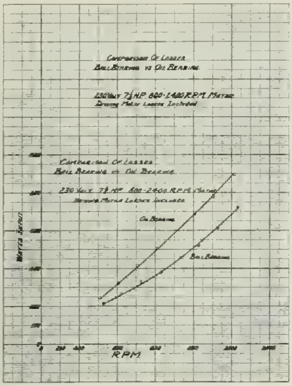

Fig. 11—Test Comparison, Ball and Oil Bearing Motor.

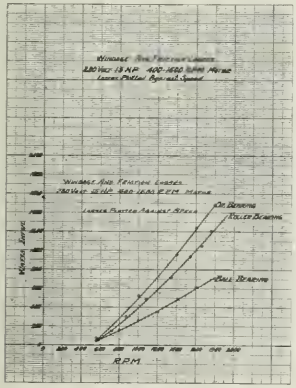

Fig. 12—Test Comparison, Ball, Roller and Oil Bearing Motor.

Figure 8 shows an application to a general service motor with the "labyrinth" type of grease groove, but this mounting does not permit of the removal of the armature without the removal of the bearings from the shaft, and therefore is not to be recommended, certainly not in a steel plant.

Figure 9 shows the application of a tapered roller bearing with the bearing completely enclosed in a cartridge. Disassembly is accomplished by removing the outer cap screws and rotating the cartridge so that the extended bosses will clear the extended bosses on the bracket. Wear on such a bearing may be compensated for by removing shims between the outer and inner enclosing caps.

Figure 10 represents the installation of a tapered roller bearing in a split frame motor. The armature may then be removed by lifting the top half of the frame. The shims for adjustment after wear are again evident.

Consideration should be given to allowing a fair sized space for lubricant and to the introduction of such lubricant through a tapped hole closed with a pipe plug, a grease cup or some other suitable means. All ball bearing manufacturers seem to be in accord that the inner race should be mounted on the shaft with a light drive fit, from .006 to .002 force, depending upon the size of the shaft. The entire paper might be devoted to a discussion of the proper fit and tolerances on ball bearings and shafts. The outer race should be a sucking fit in its housing permitting a slight creepage of the outer race if such a tendency is present. The end play should be taken on one bearing and the one carrying the heavier load is preferable. Either grease or oil may be used for lubrication; for speeds up to 2,000 rpm on 5 to 20 hp motors, grease is recommended because of the advantage in eliminating any possibility of oil getting into the motor. At very high peripheral speed, oil is found to be preferable.

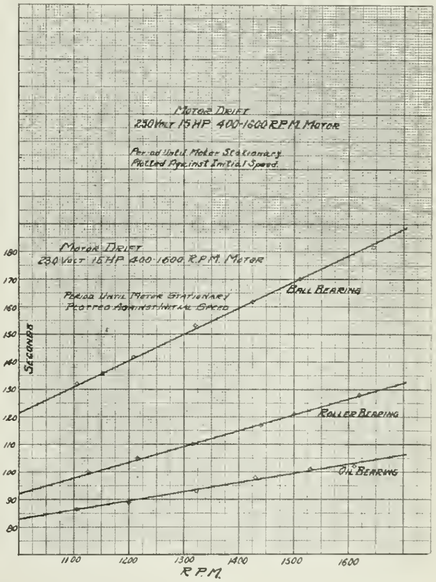

Fig. 13—Test Comparison, Time of Drift.

Care of Ball Bearings.

From the data available, it is evident that great care must be exercised to protect the ball bearing before installation in the motor and during the process of assembly against the entrance of any grit or foreign substance, as the presence of such substance will most certainly result in wear and the eventual failure of the bearing. If the armature is removed from the frame with the bearing not enclosed in a cartridge, the bearing should be carefully wrapped while the armature is out of the motor. To offset this, it is claimed that very little attention need be given to the lubrication of the bearing while the motor is in operation. There are cases on record where anti-friction bearings have operated over a period of three to four years without being greased. This is of course not recommended. Speed and heat conditions are the governing factors. Wherever possible grease should be applied at intervals of about six months. Probably the best practice would be for the operator to make monthly inspections at the time of the installation in order to judge how long the lubricant will remain serviceable under the conditions existing in that particular plant, and then establish a period for applying grease. In no case should the housing be packed full of grease as it will cause severe heating in operation. It is the practice of the ball bearing manufacturer to slush their bearings with a coating to avoid rust. Before installation, the bearings should be cleaned in gasoline to remove this slush, as it is not a good lubricant and will cause heating under certain conditions.

Arguments For and Against the Use of Anti-Friction Bearings.

The history, manufacture and application or mounting of anti-friction bearings may be of interest to the electrical engineer, but the real question which he wishes to consider is what are the advantages of such a type of bearing, and what are the disadvantages.

Advantages.

The advantages are presented in summary form compiled from the information received from the bearing manufacturers and the users of this type of bearing.

1. Absence of oil. By various steel mill electrical engineers it has been estimated that the presence of oil is responsible for from 60 to 90 per cent of their motor troubles, causing injury to the insulation, shorting of commutator bars, gumming of commutator, collecting dust and a general unsightly condition. The lubricant is more easily retained in a ball or roller bearing than in a sleeve bearing.
2. Reduction in maintenance cost. Much less frequent attention need be given to the lubrication of a ball or roller bearing. The weight of the evidence received from the users of anti-friction bearing motors is to the effect that failure of bearings is very much less frequent than on oil-ring bearing motors.
3. Reduced wear of the bearing, resulting in much less frequent renewal of the bearings due to the lowering of the rotor, and the consequent decreased air gap at the bottom. This consideration is of particular importance on induction motors with their necessarily small air gaps.
4. Increased efficiency. A record was presented of a test on a 3-hp, 1,800-rpm induction motor. Three motors were used, one equipped with ring oiler bearings, another with waste packed bearings and the third with ball bearings. The test showed the following efficiency:

Ring oiling bearing	81½%
Waste packed	80½%
Ball bearing	84½%

5. A considerably decreased torque is necessary at starting. In the case of an oil ring bearing, sufficient torque must be applied to break the contact of the shaft on the bearing metal before the oil film is established.
6. Anti-friction bearings make possible a considerable reduction in the overall length and in the weight of the end housing. Babbitted bearings are quite usually designed with the bearing length two and one-half or three times the diameter of the shaft, whereas the length of the ball bearings is usually not over one-third of the shaft diameter. A ball bearing is usually not over one-third of the shaft diameter. A ball bearing manufacturer has advised that a tabulation of standard motor sizes proves that the overall length can be reduced on an average of 15 to 20 per cent by the use of ball bearings.
7. The information received from the railroads, the government and the steel mills which have experimented with anti-friction bearings, indicate that these bearings, have been successful, and this experience should certainly be classed as a strong argument for the use of such bearings.

Disadvantages.

1. Cost. The first cost of the motor will be greater and two lines of motors will have to be manufactured as long as the users of motors are not unanimous in their opinion. If the user changes to the anti-friction type of bearings, it will be necessary for him to carry two lines of spares until all of the oil ring bearing motors have worn out or been replaced.
2. Difficulty in making replacements. It does not seem that it will ever be possible to replace a ball bearing as easily as an oil ring bearing. To secure proper operation, it is necessary that the inner race be tight on the shaft, which prevents its easy removal. For steel mill operation, it may be necessary to carry complete armatures with bearings assembled. This would certainly not be justified unless the reduction in the number of bearing troubles more than compensated for this extra expense.
3. The care which is necessary in successfully mounting anti-friction bearings and assembling the armature in the frame. The oil ring type of bearing does not require the careful assembly needful with an anti-friction bearing.
4. It is essential to very carefully protect anti-friction bearings in handling and installation. This is readily recognized as a disadvantage in the steel plants.
5. The workman in the steel mill is unfamiliar with the mounting of anti-friction bearings, and the assembly of such motors. This must be charged up as a disadvantage until such time as the average worker becomes sufficiently familiar with this type of motor to be able to disassemble it without any difficulty or detailed instruction.
6. In cases of armature grounding, current may pass through the balls or rollers and the races, causing pitting; in extreme cases actually fusing the race to the balls or rolls.
7. Under emergency conditions where a spare bearing is not available, the oil ring type of bearing may be babbited or cast by any reasonably good workman. This is not possible with the anti-friction type.
8. The strongest argument against the use of the anti-friction bearings, or any other device is the fact that it has not been thoroughly proven under actual operating conditions. Whether or not the anti-friction bearing will stand up as well as oil ring bearing under shock and unusual load conditions has not yet been conclusively demonstrated. Until the case for the anti-friction bearings has been firmly established, they must be recognized as being on trial.

Illustrations 11, 12 and 13 represent the results of tests conducted under the direction of the writer.

In the first case, illustrated by Fig. 11, two motors normally rated at 7½ hp, 850 rpm, with 9¼-inch diameter armature, were at different times belt driven by the same motor. One of the machines under test was equipped with oil ring bearings and the other with ball bearings. In all other ways the two test machines were identical. The watt input represents not only the friction and windage losses of the machine under test, but also the losses of the driving motor. However, since the driving motor was the same in each case, the difference between the losses will represent the saving of the ball bearing over the oil ring bearing.

The second case, illustrated in Fig. 12, represents a somewhat similar test conducted on three motors normally rated, 30 hp at 850 rpm. Motors were identical excepting the bearings; one was equipped with oil ring bearings, a second with Hyatt roller bearings and the third with Hess Bright ball bearings. In this test the losses of the driving motor were deducted from the watt input, and the only inaccuracy is that the losses shown include the belt loss. It is interesting to note that at slow speeds, the reduction in loss with the use of ball bearings is not nearly so apparent as at high speeds. It is further interesting to note that the loss with roller bearings falls between the loss with oil bearings and with ball bearings, and more closely follows the line of the oil bearing loss at the high speed.

The third case, illustrated by Fig. 13, represents the test on the same three motors with the number of seconds that the armature would rotate after shutting off the power, plotted against the speed. The results in this test quite closely checked in quantitative value the tests represented in Illustration 12. Sufficient tests have not been made to present conclusive evidence, and a great many more should be conducted, but as far as the investigation has proceeded it would appear certain that motors equipped with anti-friction bearings result in a saving of power.

While the railroads have had a very successful experience with car lighting generators, so equipped, their experience with head light generators has not been the same. In the early history of anti-friction bearings applied to motors appear many cases of complete failure, and while this may have been due to misapplication or to improper mounting, these examples must be lived down, before the anti-friction bearing receives a clean bill-of-health. It is somewhat doubtful whether this type of bearing is satisfactory with heavy armatures having considerable distance between the bearing centers and operating at high speed. There have been quite a large number of failures under such conditions, resulting in excessive vibration and in the peening under the inner race. This trouble has been particularly evident on two bearing arc welding motor generator sets. Additional detailed evidence was presented in this paper under the head of "Experiences of Users and Manufacturers."

Waste Heat Utilization for Steam Generation

By G. R. McDERMOTT.

THE purpose in presenting this paper is to bring to the attention of the members of the Association what has been accomplished in the utilization of waste gases for the purpose of steam generation and to point out sources of waste heat which may be available.

The term waste heat is inclusive of the total heat left in gases of combustion when they have served their primary purpose of roasting, reducing, oxidizing or heating in industrial or metallurgical furnaces or kilns. Furnaces employing regeneration or recuperation commonly have left in the gases of combustion, leaving the furnace from 35 to 55 per cent of the total heat available in the fuel fired. Non-regenerative furnaces may have as high as 80 per cent of heat in the fuel escaping in waste gases of combustion. Kilns, oil stills, glass tanks, water gas sets, etc., all present, on account of the amounts and temperatures of escaping gases of combustion, amounts of waste heat that are not only recoverable, but that give returns which will net from 25 to 75 per cent in one year on the installation cost of the quipment.

The past three years have seen marked increases in the price of coal and we should utilize the waste heat available, not only as an individual plant economy, but as a conservation of the national resources.

The very first studies that were made and the first successful application of waste heat boilers for furnaces with regenerators was effected at the Illinois Steel Company, South Chicago. The first installation was operated in 1910 and upon the very important discoveries then made have been based the rapid developments and applications of the modern waste heat boilers.

Before taking up the different sources of waste heat, it, no doubt, will be of interest to consider the heat and absorption phenomena obtained in a direct-fired boiler and that of a modern waste-heat boiler.

Many experiments have shown that the heat absorbed by radiation is proportional to the fourth power of the absolute temperature difference between the radiating surfaces. Considering a stoker fired boiler with combustion temperature at 2700 degrees F., and a waste-heat boiler at 1300 degrees F. initial temperature, the absorption by radiation would be as

$$\frac{T^4 \text{ (coal)}}{T^4 \text{ (waste heat)}} \;..\; \frac{2700^4}{1300^4} \;..\; \frac{10.5}{1}$$

The absorption by radiation in the case of the direct-fired boiler will be ten times as great as in the case of the waste-heat boiler.

Usually about 65 per cent of the total evaporation is by radiation and 35 per cent by convection, as, for example, in a 600 hp boiler, 7,025,000 Btu. are absorbed by convection and 13,050,000 Btu. by radiation. In the waste-heat boiler only 1,300,000 Btu. can be absorbed by radiation, leaving 18,700,000 Btu. to be absorbed by convection. Therefore, the rate of heat transfer by convection must be, for waste heat boilers, 2.75 times greater per square foot of heating surface. This difference is further aggravated by the fact that

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in the modern waste-heat boiler the amount of heating surface exposed to the radiant that of the furnace is very much less in proportion to the total heating surface as in the case of the direct-fired boiler.

Obviously for a given gas weight, starting in with an initial temperature of 2700 degrees F. and 1300 degrees F., respectively, passing through or past an identical heating surface of a boiler, and having identical exit temperatures, the net amount of heat absorbed by convection by the heating surface must be much greater for the waste heat boiler with initial temperature of 1300 degrees F. For each square foot of heating surface of the boiler, therefore, the heat transferred by convection must jump to a figure hitherto considered impracticable. This point of view is not always appreciated. It is not infrequently felt that since a low temperature waste heat boiler gives but 70 to 80 per cent of builders' rating that the heat transfer rate is low. Actually it is very high.

An increase in heat transfer rate is accomplished by an increase in velocity. Consideration of the formulae governing this phenomena will develop the reasons.

The rate of heat transfer for either fire-tube or water-tube boilers may be expressed in the form

$$R = \frac{H}{T - t} = a + b\,\frac{W}{A}$$

where

R = heat transfer rate in Btu. per hour per square foot of heating surface per degree F. difference in temperature.

H = Btu. transferred per hour per square foot.

a and b = Constants.

$\frac{W}{A}$ = Mass velocity expressed as pounds of gas per hour per square foot of area of gas passage.

In general the constant "a"

1. is greater for water tubes than for fire tubes of same size.
2. is greater as diameter of tube decreases.
3. is greater as space between water tubes decreases.

Similarly, constant "b," which is the inclination of the line representing "R" when plotted against mass velocity.

$$\frac{\text{"W"}}{\text{"A"}}$$

1. Is greater for water tubes than for fire tubes.
2. Is greater as diameter of tube decreases.
3. Is greater as temperature difference between steam and water increases.

For the constants "a" and "b," values may be assigned that are sufficiently accurate for all ordinary engineering applications and are derived from reliable tests and investigations conducted by boiler companies and independent observers.

The following formulae are given as they illustrate the relative heat absorbing characteristics of the two types of boilers, the data being taken mainly from tests made by the Babcock & Wilcox Company on both fire-tube and water-tube boilers; by Messrs. Kreisinger and Ray, on small fire-tubes, and confirmed by tests on two-pass waste heat boilers later described in this paper.

Outside Diameter of Tubes—Inches	Fire Tubes	Water Tubes
1	$R = 3.5$ plus $.0013\,\frac{W}{A}$	
2	$= 2.0$ plus $.0008\,\frac{W}{A}$	
3	$= 1.5$ plus $.00065\,\frac{W}{A}$	
4	$= 1.1$ plus $.0005\,\frac{W}{A}$	$R = 2.0$ plus $.0014\,\frac{W}{A}$

These values apply to 400 degrees F. mean temperature difference corresponding approximately to waste-heat boiler conditions.

As stated before, the absorption of heat from waste gases covered in this paper must be done largely by convection; that is, the molecules of the flowing gases come in contact with the heating surface of the boiler and impart their heat to it. The rate at which the heat is imparted to a unit surface depends, therefore, on the number of gas molecules coming in contact with it. By referring to the above equations of "R" for different tube diameters, it will be noted that "R" increases with a reduction in the value of "A," or, in other words, with an increase in the mass velocity. This is explained by the fact that the faster the gas moves, the greater the number of molecules or particles of gas that pass each unit of heating surface in a unit of time, and, consequently, the greater the number of hot molecules that will hit or penetrate into the adhering gas film and replace cold molecules of gas. Thus, the dislodging effect of these moving molecules on the molecules of the adhering film is proportional to the velocity of the mass of the gas moving over the heating surface. This absorption phenomena manifests itself to a greater degree when the gases are at or above their "critcal velocity." The term "critical velocity" is that velocity at which the stream lines of flow cease rather suddenly to be parallel, and at which violent eddying begins. This may be illustrated by a thread of colored liquid introduced into the center of a stream of water flowing through a tube. Below a certain velocity the thread of color will remain in the center and quite sharply defined for the entire length of the glass tube; however, with an increase in the velocity the color will disappear or become diffused, indicating that the "critical velocity" has been reached. The violent eddying, due to the gas being at or greater than its critical velocity, will cause a greater number of the gas molecules to hit the tube wall and thereby release their heat. Obviously, the smaller the diameter of fire tube, the closer the gas molecules are to the surface, the sooner they will reach it and the greater the number of contacts each will make in a unit of time. This accounts for the increase in the value of "R" with reduction of flue diameter as given above.

Although the rate of heat transfer at a given mass velocity and the diameter is greater for a water-tube boiler, yet the friction loss of the fire-tube boiler is much less. For example, the average of tests on nine (9) waste-heat boiler installations, using cross baffled water-tube boilers having four-inch tubes shows:

Mass Velocity $\frac{(W)}{(A)}$	Rate of Heat Tranmission (R)	Draft Loss
2,400	5.42	2.07 in.

If a fire-tube boiler, as described later, using three-inch tubes, were used, the conditions would be:

7,630	6.45	2.07 in.

To illustrate this point still further, figures are here presented showing that a fire-tube boiler may be designed that will have less than one-half the heating surface of a horizontal cross-baffled water-tube boiler, and still give the same performance under the same operating conditions. As a basis for comparison, an average size of standard type of water-tube boiler and operating conditions are taken from actual practice.

Published results of tests on seven (7) waste-heat boilers, all of similar horizontal water-tube type with four-inch tubes and cross baffling, show the following averages:

Rate of heat transfer, Btu	5.32
Draft loss—ins. water	1.45
Heating surface—sq. ft	5,030
Weight of gas—lbs. per hr	68,330
Initial temperature—deg. F	1,330
Stack temperature—deg. F	470
Boiler hp.	400

These figures indicate in a general way what may be expected from specially adapted types of water-tube boilers as ordinarily installed and operated. The mass velocity corresponding to the above average heat transfer rate, as computed by formula

$$\text{“}R = 2 \text{ plus } .0014 \frac{W}{A}\text{”}$$

is 2,370 pounds per hour per square foot of passage area.

For the sake of comparison, let us consider some fire-tube boilers so proportioned that the same amount of gas will cause the same loss of draft, viz.: 1.45 inches. Tube sizes are assumed as 1, 2 and 3-inch diameter, as this selection illustrates the super advantages of using small tubes. Three cases are worked out as follows:

Type of Boiler	Horizontal Water Tube	Double Pass Fire Tube	Single Pass —Fire Tube—	
Size of tubes, outside dia.	4 in.	3 in.	2 in.	1 in.
Number of tubes	....	282	525	1,830
Length of tubes—ft.	....	28	14	5
Heating surface—sq. ft.	5,030	5,700	3,400	1,966
Weight of waste gas—lbs. per hr.	68,000	68,000	68,000	68,000
Mass velocity—lbs. per sq. ft.	2,370	5,900	8,000	8,500
Rate of heat transfer—Btu.	5.32	5.34	8.4	14.6
Draft loss—ins. water	1.45	1.45	1.45	1.45
Initial tempt.—deg. F	1,330	1,330	1,330	1,330
Stack tempt.—deg. F	470	470	470	470
Boiler hp.	400	400	400	400

Inasmuch as the rate of heat transfer at high mass velocity varies almost in proportion to the mass velocity, it is obvious that the number of tubes may be decreased without materially affecting the evaporation. This greatly reduces the first cost and the only disadvantage—if, indeed, it be a serious one at all—is the increase in friction loss. For example, the evaporation obtained in the boiler with 1,880 one-inch tubes, five feet long, may be equally well obtained with only one-half the number of tubes by merely increasing the length to 5.25 feet, as

Size of tubes	1 inch O. D.
Length of tubes	5.25 feet
Number of tubes	915
Heating surface	1 130 sq. ft.
Weight of gases	17,000 lbs. per sq. ft.
Mass velocity	68,000 lbs. per hr.
Rate of heat transfer	25.5 Btu.
Draft loss	6.15 inches
Initial gas temperature	1,330 deg. F.
Stack temperature	470 deg. F.
Boiler hp.	400

The greater friction loss may be compensated for by increasing the length of tubes so as to obtain sufficient additional evaporation to carry the greater load on the fan.

The point is often raised that tubular boilers are not so efficient as water-tube boilers. This is perfectly natural when only the usual types of tubular boilers and methods of using them are considered. As a matter of fact, the heating surface of tubular boilers can be made as effective or even more so than that of water-tube boilers. The trouble with the usual fire-tube boilers, especially when used for waste heat applications, is that the area for the passage of gases is too large and there is not sufficient length of travel for the gases. These objections are, of course, overcome by making a long boiler of smaller diameter, or, what amounts to the same thing, dividing the boiler into two or more passes. The matter of tube size is also a large factor and if the question of cleaning were not of such real importance, the tubes could to great advantage be as small as locomotive tubes, or even smaller.

Appreciating the above-mentioned advantages of the fire-tube boiler induced Mr. C. J. Bacon, formerly steam engineer at the South Chicago works of the Illinois Steel Company, to design a fire-tube type of boiler embodying the modern ideas of a waste-heat boiler.

The Bacon waste-heat boiler is designed to utilize at the maximum net economy the heat in waste gases from metallurgical and other industrial heating furnaces. It possesses special features that have been found to make it particularly well adaptable to the conditions peculiar to the majority of applications. The initial installations were in conjunction with open-hearth furnaces in steel works where the operating conditions and other limitations interfered with obtaining satisfactory results from standard types of boilers.

Obviously, in order that the first cost may be low and that the boiler may have the desired evaporative capacity, it is essential that the design contain such features as to permit condensing the heating surface into the smallest possible space. This in turn requires that the rate of heat transmission through the heating surface be proportionately high. Data resulting from various authoritative tests makes it possible to predict with accuracy what the heat transmission and, consequently, the evaporation will be. As usually built, the Bacon boiler consists of two vertical cylindrical shells, between the heads of which are rolled and electrically welded a large number of small tubes in a similar manner to vertical fire-tube boilers. The diameter of tubes is kept as small as permits cleaning and the length is determined mainly by the space available and the friction loss. The object is to insure that the gases have a long travel at high velocity. In some cases it is found desirable that the average velocity exceed 100 feet per second for the purpose of preventing dust from lodging and to give a high rate of heat transmission. The waste gases enter the gas box at the bottom of the first pass, whence they pass upward through the tubes and into the transfer flue which directs the flow downward through the second pass, and in the case of an installation recently finished a third pass, which will act as an economizer.

In some forms of construction of the Bacon boiler, a single shell is set horizontally and the two passes are obtained by suitable baffling in the steel gas boxes at the ends of the shell. For application to small furnaces, this is a better arrangement than the double vertical shell design.

Boiler scale trouble is minimized on account of feed water being admitted at the bottom of the second or "cold" pass. Here it becomes gradually heated and rises to the top of the pass. The water then passes from the second pass through an exterior water circulating connection to the bottom of the first or "hot" pass. As but one-third of the heat is utilized in the second pass, where gas temperatures at the bottom are not over 560 degrees F., the sludge deposited is not hard and may readily be blown off through the several blow-off connections. The principle of forced water circulation on a counter-current principle gives a high rate of heat transfer. Liberal hand-hole access is provided and blow-off valves are arranged to drain the bottom tube sheets.

As a rule, natural draft is not sufficient because the gases leaving the boilers have been cooled to 450 degrees or 500 degrees F. in the attempt to recover as much of the heat as possible. On this account and because the intensity of draft required for operating the industrial furnaces and for drawing the gases through the boiler, it becomes necessary to use induced draft fans. When properly installed and driven, the fans prove a very advantageous accessory from the standpoint of better control of the operation of the heating furnaces, and, with correctly selected turbine drive, the exhaust steam suffices to heat the boiler feed water.

While fans are a necessity regardless of the type of boiler used, the amount of power they require is much less with the fire-tube boiler than with water-tube boilers in brick settings. It is not at all unusual that the amount of air leakage through brick settings and other loose joints is sufficient to increase the fan load 80 per cent over what it would be without leakage. Moreover, the leakage reduced the evaporation to a serious extent, due to cooling the gases. Thus it is seen that a type of boiler having no brick settings is the logical solution of the air leakage problem. Casing the boilers in sheet steel reduces the trouble, but does not stop it since much leakage is past brick-to-mental joints. Moreover, it increases the cost of installation. The great difference in draft that exists in a baffled water-tube boiler on the two sides of the baffles causes short circuiting of gases, through leaky baffles, consequently lack of contact with tube surface and high stack temperatures. With fire-tube boilers trouble of air leakage from exterior or short circuiting of gases through baffles cannot occur. There is no brick work except linings of flues and gas boxes and these are of steel plate construction.

Explosions in the waste gas flues and in waste-heat boilers are characteristic of open-hearth furnaces using pre-heated gas. Leakage, especially, promotes explosions in the boiler setting at times of reversal. These explosions strain the settings, loosen the brickwork and increase the air leaks of water-tube settings. As an actual matter of fact, these leaks develop into serious conditions, particularly if repairs are not made promptly in every-day operation. Consequently, evaporation falls off continuously and it is a matter of record at many plants that air infiltration is such a serious factor that maintenance of economic steaming and furnace performance is a practical impossibility. Explosions cannot injure the fire-tube boiler.

Where the waste gases contain dust in a fine and adherent condition, it packs closely onto the tubes of the water-tube boilers. This is indifferently removed by mechanical soot blowers. Due to the high velocity of the gases causing a sweeping action, the dust does not readily collect on the surface of the vertical flues.

Another factor in favor of the fire-tube type of waste-heat boiler is for equal evaporation it requires but two-thirds to three-quarters the cubic space required by the water-tube type of boiler.

Source of Waste Gases.

In order to investigate the value and thereby the saving which may be made by utilizing the waste gases for the generation of steam it is, of course, necessary to determine the quantity and temperature of waste gas available.

A specific exhibit of the method in arriving at these quantities will, no doubt, aid those contemplating an investigation of waste heat recovery. The author has selected the open-hearth furnace as perhaps being the most difficult in determining the weight of gas available.

Source of Gases from an Open-Hearth Furnace
Typical Heat Data

Size of heat	75	tons (ingots)
Tons hot pig iron charged	42.75	
Tons cold pig iron charged	.57	
Tons iron scrap charged	6.10	
Tons steel scrap charged	32.50	
Pounds ore charged	14,200	
Pounds limestone charged	15,100	
Pounds dolomite charged	5,265	
Pounds fluorspar charged	762	
Pounds silicon (10 per cent) charged	262	
Tons coal charged at producers	23.70	
Time of heat	9 hr. 25 min.	
CO content of waste gases	13.00	per cent
Tempt. of waste gases from checkers	1,300	deg. F.
Heat value of coal (Illinois)	10,000	Btu.
Percentage of pig iron	56.0	
Percentage of scrap	36.8	
Percentage of ore	7.2	

The gas producing elements of the charge are the pig iron with 4.35 per cent carbon, 0.85 per cent silicon and 1.75 per cent manganese; the limestone with 42 per cent carbon dioxide, and the coal with the following analysis:

Analysis (Natural)

Carbon, per cent	60.10
Hydrogen, per cent	4.36
Nitrogen, per cent	1.18
Oxygen, per cent	10.97
Sulphur, per cent	1.42
Ash, per cent	8.43
Moisture, per cent	13.54

The steel scrap charged is considered a neutral component, being essentially of the carbon and metalloid content of the steel produced. The dolomite and fluorspar contribute negligible amounts of carbon dioxide to the gases. The ore charged, averaging 89 per cent ferric oxide, is significant in that the oxygen available therein for combining with the carbon of the pig iron reduces the amount of air with its nitrogen diluent, otherwise required for oxidation.

To reduce the data to pounds of gas per hour available for steam generation, the open-hearth practice must be reduced to the following figures:

Rate steel produced per hour....	7.96	tons ingots
Coal per ton ingots..............	701	lbs.
Ore per ton ingots..............	189	lbs.
Pig iron per ton ingots..........	1,475	lbs.
Limestone per ton ingots........	200	lbs.
Silicon	3.5	lbs.

Gas from pig iron charged per ton steel:

4.35 (carbon in pig iron) less 0.20 (carbon in steel) = 4.15 percentage carbon burned out of pig iron

$1475 \times .0415 = 61.2$ lbs. carbon burned out of pig iron
$61.3 \times 2.666 = 163.0$ lbs. oxygen required for carbon
$189 \times 0.265 = 50.0$ lbs. oxygen available in ore
$163.0 - 50.0 = 113.0$ lbs. oxygen required from air

$$\frac{113 \times .768}{.232} = 375$$ lbs. nitrogen in gas from accompanying oxygen.

$61.2 + 163.1 = 224.3$ lbs. CO_2 from pig in gas

Gas from limestone charged per ton steel:

$200 \times 0.42 = 84$ lbs. CO_2

Gas from silicon and manganese charged per ton steel:

$1.75 + .85 = 2.60$ percentage silicon and manganese in pig iron
$1475 \times .026 = 38.5$ lbs. Mn. and Si. in bath

$$\frac{38.5 \times 0.8 \times .768}{.232} = 102$$ lbs. nitrogen in waste gases from oxidation of Si. and Mn.

Total carbon dioxide from charge = 308 lbs.
Total nitrogen by charge = 477 lbs.

Gases from coal burned at producer:

$$11.52\,C + 34.56\left(H - \frac{O}{8}\right) + 4.32\,S =$$

$$11.52 \times .601 + 34.56\left(.0436 - \frac{.1097}{8}\right) = 8.01$$ lbs. air required per lb. coal

plus $4.32 \times .0142$

Analysis burned gases (0.0 per cent excess air):

CO_2 $.601 \times 3.67 = 2.2$ lbs. CO_2
O_2
N_2 $8.01 \times .768 = 6.15$ N_2 from air
.15 N_2 from coal
H_2O $.0436 \times 9 = .39$ H_2O from H in coal
.1354 H_2O from coal
.07 H_2O from air 75% humidity
.50 H_2O from steam
9.59 total weight gas per 1-lb. coal
$701 \times 9.6 = 6{,}370$ lbs. total weight gas from coal per ton ingots.

Per cent by weight:

	Wet	Dry
CO_2	22.85	25.8
N_2	65.75	74.2
H_2O	11.40	....

The CO_2 content of 13 per cent in the stack gases as compared to 19.2 per cent in gases from charge and coal undiluted with air indicates an addition of air of 47.5 per cent to the gases. This is, in part, supplied through the ports, and in part by leakage at the doors, ports and checkers. The indicated addition of 47.5 per cent air to 7,509 pounds gas will total 3,591 pounds of air per ton of ingots, giving 1,848 pounds CO_2, 833 pounds of oxygen, 7,651 pounds nitrogen, and 768 pounds moisture, or a total weight of gases of 11,100 pounds. Per hour we have 88,500 pounds of gas. As an approximate check on these quantities of gas, one may divide the total carbon in coal, pig iron and limestone, or 503 pounds, by the carbon in one cubic foot of waste gas containing 13 per cent CO_2, or 0.044 pound. This gives us 91,000 pounds per hour.

Analyses of Total Waste Gases—No Air Dilution Per Ton Ingots

Content	Lbs.	Total Lbs.	Analysis—Dry Weight	Analysis—Dry Volume
CO_2 from charge	308			
from coal	1540			
Total		1848	27.4%	19.2
N_2 from charge	477			
from coal and combustion	4416			
Total		4893	72.6%	80.8
H_2O from coal and steam....	768	768		
Total weight of gases per ton ingots		7509		

At 1,300 degrees F. there are 26,000,000 Btu. in the waste gases, as against 60,000,000 Btu. in coal charged, or 43 per cent of total heat charged, equivalent to 2,400 pounds of coal hour.

As an illustration of the practical application of the modern fire-tube type of waste heat boiler, a description and evaporation test of an installation follows:

Fire-Tube Waste Heat Boilers Installed on Open Hearth Furnaces.

The installation consists of fourteen (14) boilers, one Heine, two Stirling water-tube, and eleven (11) Bacon fire-tube boilers. A test was conducted on one Bacon fire-tube utilizing waste gases from an open-hearth furnace. Each unit consists of a superheater, a two-pass vertical fire-tube boiler, and an exhaust fan driven by a steam turbine.

The superheater consists of two units with elements set in a vertical position in the horizontal flue near the first pass of the boiler.

The boiler consists of two vertical passes 82 inches in diameter. The first pass contains 282 three-inch flues, 16 feet long, and the second having a like number, but 12 feet long. The tops of the two passes are set at the same height and each has a 16-inch nozzle located 12 inches from the top flue sheet and connected to a 4-foot 0-inch x 7-foot 0-inch steam drum. The bottom of the steam drum, which is about 30 inches below the top of the passes, is connected to each of the two passes near the bottom by a 12-inch water leg. Feed water enters this water leg from which it flows to the bottom connection of each pass. The water level is carried about 14 inches below the upper flue sheet. This gives about 92 per cent of the heating surface as effective for evaporation.

The second pass is equipped on top with a permanent soot blower, while a hand lance is used on the bottom of the first pass and superheater for cleaning flues.

The waste gases are handled by an overhung wheel single inlet fan. Capacity 80,000 pounds of gas per hour at 500 degrees F., with static difference of 5.5 inches at 1,115 rpm. Efficiency 75 per cent, requiring 37.5 hp. The fan is driven by a steam turbine, standard non-condensing 3,985 rpm rated 37.5 Bhp. The change of speed is made by a set of herringbone speed reduction gears of 3:57 to 1 ratio. The gases are taken from the main furnace flue, immediately before entering the stack, pass through a horizontal brick flue 4-feet 0-inches wide x 6-feet 9-inches high, equivalent to an area of 27 square feet, to the superheater, thence through the same sized flue to directly underneath the first pass, taken up through a 5-foot 3-inch diameter brick-lined flue and through the first pass, then across the transfer flue, down the second pass and out to the fan. The fan discharges the gases back into the main stack again immediately above the roof line. The boiler is equipped with suitable dampers before the superheater and after the fan to by-pass the boiler.

The feed water passes through a hot water continuous softener of 15,000 gallons per hour normal rating, located in the vicinity of the open hearth. The exhaust steam from the fan turbines and the three reciprocating feed pumps is used in heating the feed water while passing through the water softener.

Evaporation Test.

Feed water was measured in tanks of known dimensions and feed water temperature was taken with a thermometer. Tell-tale valves were installed in feed line to avoid any possible error in feed water piping. The blow-off valves all terminate in a pit and this was observed to correct any possible leakage. These valves were tightly closed and no leak found.

Temperatures of gases before the superheater, between the superheater and boiler, and between the two passes were taken with thermo-couples which were checked immediately before the tests. The temperature of gases between second pass and fan, also temperature of superheated steam, was taken with mercurial thermometer.

Drafts were taken with manometers and were checked frequently to avoid error with changes of temperature.

The steam consumption of the fan turbine was obtained by a recording steam flow meter installed in the 2½-inch steam line to the turbine. Each test was run from tap to tap of the furnace, but the first two hours of the last test were thrown out on account of having gas turned off for a few minutes due to furnace troubles. Table No. 1.

Soaking Pits and Re-Heating Furnaces.

Soaking pits and re-heating furnaces are other sources of waste heat recovery. The number, arrangement, and location of the pits and furnaces will determine the desirability and feasibility of an installation.

For example, the author has in mind one plant where there are ten (10) pits arranged in a row. Investigations made to determine the quantity and temperature of the waste gases demonstrated that with producer gas as fuel, there was available 26,000 pounds of waste gas per pit hour. The gas had an average temperature of 1,165 degrees F. at the base of the stack.

By an arrangement of underground insulated flues and suitable dampers such as to combine the gases from three or four pits to a boiler, it was estimated that 1,100 Bo. hp net would be developed based on 90 per cent operating time. The return on the investment in this case represented 45 per cent.

Table No. 1

Results of Tests

Date	June 14, 1918	July 1, 1918
Duration	9 hr.55 min.	7 hr. 50 min.
Pressures—		
Steam at boiler—lbs. per sq. in.	144.6	143.5
Steam after superheater—lbs. per sq. in.	143.0	142.0
Loss through superheater—lbs. per sq. in.	1.6	1.5
Steam in turbine steam chest—lbs. per sq. in.	91.7	116.0
Exhaust steam from turbine—lbs. per sq. in.	0.0	0.0
Barometer—lbs. per sq. in.	14.45	14.5
Drafts—		
Before superheater—ins. water	1.45	1.26
Before boiler—ins. water	1.81	1.70
In transfer flue—ins. water	2.65	2.52
Before fan—ins. water	3.51	3.28
In fan discharge—ins. water	0.96	0.81
Drop in draft before superheater to fan inlet—ins. water	2.06	2.02
Drop in draft through superheater—ins. water	0.36	0.44
Drop in draft through first pass—ins. water	0.84	0.82
Drop in draft through second pass—ins. water	0.86	0.76
Drop in draft through boiler—ins. water	1.70	1.58
Total draft across fan—ins. water	2.55	2.47
Temperatures—		
Waste gas before superheater—deg. F.	1451.2	1372.6
Waste gas after superheater and before boiler—deg. F.	1269.4	1205.7
Waste gas in transfer flue—deg. F.	793.2	723.4
Waste gas before fan—deg. F.	556.2	525.0
Feed water—deg. F.	177.7	181.0
Steam leaving boiler—deg. F.	363.0	362.0
Steam leaving superheater—deg. F.	507.0	472.0
Superheat—		
Due to boiler—deg. F.	0	0
Due to superheater—deg. F.	145.0	110.0
Total superheat—deg. F.	145.0	110.0
Calorimeter—		
Temperature of steam—deg. F.	296.65	314.6
Pressure of steam—ins. hg	4.42	4.81
Quality of steam—per cent	99.5	100.0

	—June 14, 1918—		—July 1, 1918—	
Water—	Bo. Only	Bo. & Suphtr.	Bo. Only	Bo. & Suphtr.
Water per Hour—				
Total fed to boiler	129,685	129,685	100,990	100,990
Factor of evaporation	1.081	1.162	1.077	1.134
Equiv. evap. F. & A. at 212°	140.200	150,700	108,600	114,500
Fed to boiler—lbs.	13,086	13,086	12,890	12,890
Equiv. evap.—lbs.	14,150	15.210	13,885	14,630
Horsepower	410	441	403	424
Net Bo. hp deducting turbine steam	371.3	402.3	364	385

	—June 14, 1918—		—July 1, 1918—	
Gas Analysis—	Before Suphtr.	Before Fan	Before Suphtr.	Before Fan
CO_2—per cent	14.20	12.48	14.5	12.1
O_2—per cent	5.61	7.17	5.4	7.0
CO—per cent	0.0	0.0	0.0	0.0

	June 14, 1918	July 1, 1918
Opening of damper to stack—(average)	0	0
Steam per hour to turbine—lbs.	1148	1205
Boiler hp of turbine	38.7	39
Turbine speed—rpm	3486	3589
Density of gas at 62° F.—lbs.	.07893	.07893
Heat absorbed from gases by steam per hr. Btu.	13,730,000	13,492,000
Coal equivalent lbs. per hour	1250	1220
Heat radiated per hour—Btu. (assumed)	500,000	500,000
Total heat absorbed and radiated—Btu.	14,230,000	13,992,000
Total tempt. drop across boiler—deg. F.	713.2	680.7
Weight gases per hr. through boiler—lbs.	79,800	82,300
Evaporation in first pass—per cent	67	70.8
Evaporation in second pass—per cent	33	29.2
Per cent drop in tempt. between inlet and outlet of available heat	78.7	80.7
Rate of heat transfer, Btu. per hr. per sq. ft. of heating surface per degree mean tempt. difference between gas and steam	5.93	6.31

In making an investigation, as mentioned above, to determine the quantity and temperature of gases available, precautions should be taken to stop all unnecessary cracks and openings around valves, and in the flues leading to the point of observation. Otherwise, determinations made would not represent the condition which might be obtained. As, for example, when observations were first taken, it was found that the stack temperatures only averaged in the neighborhood of 825 degrees F. This difference of temperature was, of course, due to air infiltration, while not in this particular case affecting the economic operation of the pit, would lead to erroneous conclusions from the standpoint of waste heat utilization.

The following is a drawing showing a proposed installation of waste heat boilers for soaking pits.

Electrification of the Steel Plant Railroad

By R. B. GERHARDT.

"ELECTRIFICATION of main line railroads in this country, up to the present time, has, in general, been for special purposes, such as to relieve congestion or for terminal work. Only a very few roads have electrified with the view of handling general freight and passenger traffic."

"There are four reasons for electrification at the present time; these are as follows:

1. Tunnel Electrification.
2. Terminal Congestion (also smoke nuisance).
3. Grades.
4. General Economies and Increased Capacity."

"Some of the roads which are electrified for tunnel work only are the Boston and Maine (Hoosac Tunnel), the Grand Trunk R. R. (St. Clair Tunnel). The Great Northern R. R. (Cascade Tunnel), and the Michigan Central (Detroit River Tunnel)."

"Some of the roads which have electrified terminals in order to reduce congestion and smoke nuisance in the approaching tunnels are the New York, New Haven & Hartford R. R., the Pennsylvania R. R. (at New York and at Philadelphia), the New York Central, and the Baltimore and Ohio."

"Roads which have electrified primarily on account of grades are the Norfolk & Western and the Chicago, Milwaukee & St. Paul."

"Roads which have electrified in order to obtain the general economies resulting therefrom together with increased capacity are the New York, New Haven & Hartford, the Norfolk & Western, Chicago, Milwaukee & St. Paul, and the Butte, Anaconda & Pacific. As may be observed, there are only four main roads as yet electrified which haul general traffic. The other electrifications are of such a nature that there is no opportunity for classifying or switching of any considerable amount of freight. However, it is interesting to know that a number of the roads have had projects under way for the electrification of classification yard, the chief of which are the Pennsylvania R. R. (the new freight yard between Fifty-second and Overbrook, just outside of Philadelphia), and the Baltimore & Ohio (at Cumberland)."

"It is also interesting to note that a large number of smaller railroads handle and switch freight by electric locomotives. Some of these roads are:

Southern Pacific (Pacific Electric), Oakland, Antioch & Eastern, Piedmont & Northern, Spokane & Inland Empire, Salt Lake & Utah, Fort Dodge, Des Moines & Southern."

In practically all cases where roads have been electrified a considerable economy of operation has resulted and in all cases the electrification has permitted of more dense traffic than previously.

Considering the electrification of steam railroads in general, the following items as regards economy of operation, in addition to the fixed charges on any investment undertaken, have to be considered:

Fuel and other operating materials
Repairs
Operating Labor
Locomotive Depreciation
Hostler or Station Service.

Fuel.

Under this item the greatest saving can be shown in yard service, due to the fact that the steam locomotive in yard service is idle a much longer time than in any other class of service, and during this time the losses, figured back into fuel are very considerably greater than with the electric locomotive, particularly where the energy for such electric locomotive is obtained from a general system of power. It has been pointed out also, under this heading, "that there is no creeping paralysis gradually impairing the efficiency of the electric locomotive until temporary relief is obtained through frequent boiler washings and shifter house tinkering, as the efficiency of this unit remains very nearly constant over the entire life of the equipment." In addition to the above the steam locomotive efficiency gradually drops off from wear in the piston rings, piston and cylinder walls. With electric operation, however, there are some chances of inefficient operation due to transmission, distribution and track bonding losses, and it is essential that careful inspection be given these points the same as is given the locomotive itself. From results obtained by the N. Y., N. H. & H. Railroad Company it has been shown that for every 106.8 pounds of coal required by a steam locomotive in yard service, 38.3 pounds of coal will do the same work after electrification. (Refer to joint meeting of A. S. M. E. and A. I. E. E., New York, October 22, 1920. Statement A. L. Ralston, Mechanical Superintendent, New York, New Haven & Hartford Railroad.) This gives a ratio of 36 per cent for this class of service, but for yard work recent tests have shown that this ratio drops to 18 per cent, not taking into account coal lost in the steam locomotives

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Abstract of paper read at Association of Iron and Steel Electrical Engineers Convention, Chicago, September, 1921.

by banking the fires. With electric locomotives receiving their energy from a central power system the cost of electric power has to be compared with the cost of fuel for the steam locomotive. However, there is no coal and ashes to be handled, likewise, in the case of yard service no water. There is, however, some operating material, such as oil, grease and sand required in both cases, but the items of oil and grease are much less with the electric locomotive. Along with the elimination of fuel, ashes, and water, there can be discarded, in favor of electrification, the plants required to handle these materials.

Repairs.

Under this item the fundamental difference between the two classes of locomotives is the length of time required to make any major repairs, except possibly in the cases of turning tires and painting. Spare parts can be so easily and quickly substituted in the case of the electric locomotives, that the time for so doing will greatly overbalance that required for most repairs on the steam locomotive. An armature, motor, gear, or controller on the electric locomotive can almost be changed in the time required to cool down and empty a locomotive boiler safely for any boiler repairs, not to speak of engine cylinder repairs. With electric operation where power is taken from the general power system, the cost of any additional apparatus required for supplying current to electric locomotives, of course, has to be taken into account; likewise, an item under repairs to be considered, which does not enter into steam operation, is the maintenance of transmission, distribution and contact line systems. With electric locomotives, however, there are no restrictions imposed by any outside boiler inspection. The following figures, taken from Mr. Armstrong's paper at the New York Engineering Meeting, referred to above, are indicative of the locomotive cost on repairs for main line freight service:

Operating Labor.

	Steam Mallet	C., M. & St. P. Electric
Cost repairs per mile	60 cents	14.65 cents
Weight on drivers	240 tons	225 tons
Cost repairs per 100 tons locomotive weight on drivers	25 cents	6.25 cents

In general yard work the train crews under electric operation do not differ from those under steam operation, except that the wages of the man taking the place of the fireman are usually somewhat less. For steel plant operation considerable additional economy can be effected.

Locomotive Depreciation and Retirement.

In the case of steam it is at an appreciably higher rate than in the case of electric operation. It is generally conceded that the life of a steam locomotive averages between 15 and 20 years, as against the life of an electric locomotive of 25 to 30 years. Substantiating this I wish to point out that the electric locomotives on the B. & O. Tunnel, in Baltimore, are already in their twenty-sixth year of operation.

Hostler or Station Service.

With electric operation this service is reduced almost to a minimum. As a matter of fact if the locomotives are so designed as to allow liberal accessibility for inspection and oiling, the inspector can look after his work without necessitating the locomotive being sent to the station or shop, and the only requisite in the usual course of operation would be that the locomotive go to a specified point for taking on sand when the supply is exhausted. No fire cleaning and rebuilding is necessary; likewise, fueling, watering and washing are done away with. The electric locomotive is always ready to run and pull its maximum load with the turning on of the curent. While it is first necessary with the steam locomotive to get up steam pressure to do this work.

In the above conditions the electric storage battery type of locomotive has not been included for the reason that a greater saving of electric operation over steam is shown by the use of straight electric locomotives only. If the storage battery machine is considered each of the above items would be increased over straight electric locomotive operation except the item—"Operating Labor." For yard work the storage battery machine, especially since the same can now be secured in fairly large size units, offers attractive possibilities due to the fact that no overhead or rail contact systems are required for its operation. However, the disadvantages are its not being able to withstand as rough treatment as the straight electric machine, its inability to maintain continuous service since during certain periods it must be idle for charging the battery or else exchanging batteries, and finally a high depreciation on the battery itself. A combination machine using both line contact system and battery may be used and considerable benefits derived over the straight battery machine.

Practically all of the steel plants with which we are familiar use for their dc power system direct current at a potential of 250 volts, and it is very essential for simplicity and economy to use this same potential for the electric locomotive. In most plants it should be entirely feasible to do this for the reason that dc generating or converting apparatus is so distributed that long distances of transmission are not encountered. In many cases the combination of the general plant load, which is highly diversified, due to crane and mill operations, with the railway load will considerably improve the load factor on the dc apparatus so that to handle the yard electrification it would not be necessary to install such apparatus to the full capacity required for this work.

The principal objection to the overhead trolley in the electrification of our yards is from the interference with the work of locomotive cranes. This machine is so essential in the steel plant yard that it is almost impossible to pick out any section of track where the crane will not be required to work at some time or other; otherwise, we might consider the overhead construction, except in specified places where locomotive crane work is concentrated. It may be proved, however, that such construction can be used to advantage in the general classification yards, and this is a matter for further study. One other objection to the overhead trolley is that it does not lend itself very readily to heavy operation at as low a voltage as we propose to use, and we, therefore, feel that the most satisfactory system would be the third rail. After reaching this conclusion the first question that naturally presents itself is the feasibility of a third rail in the yard from the following standpoints:

1. Safety.
2. Blocking the free passage of switchmen or other employees through the yard.
3. Danger from material or hot metal spilling or falling on rail.

4. Methods of crossing frogs and switches.
5. Method of construction through buildings or special places where conductor rail is objectionable.
6. Tie-up from wrecks.

Safety.

The best answer to the question of safety is to refer to the operation on blast furnace trestles where we have had electrified tracks with third rail construction for many years, operating at the same voltage as proposed for yard electrification. Looking over our records during this time I find that there has not been a single accident from contact with the live rail. There have been accidents on the trestle due to other causes, but none can be attributed to the electrified condition of these tracks. Two hundred and fifty volts is the common plant voltage which our workmen are thoroughly familiar with, and particularly the yard department employees who have anything to do with locomotive cranes or handling of lifting magnets. If we would have to go to any higher voltage, then the proposition would be considerably more hazardous. There are essentially two kinds of third rail contact systems, one using the over-top contact and the other underneath contact, and we prefer the latter for steel plant work due to the fact that it can be better insulated and more substantially protected from material falling into the rail and causing any trouble. With this type of construction, it is almost impossible for anyone to come into contact with the live rail, except by getting down underneath of the guard on either side and touching the head of the rail, which extends slightly below the guard; whereas, with the overtop contact there is not formed nearly as good a support for the guard and anyone stepping on this guard or anything falling on same is very apt to break through and come in contact with the live rail, also it is entirely possible to come in contact with the rail from the side toward the track which is entirely exposed. The underneath contact system lends itself more readily to a very close fitting guard, thus taking up considerably less space than the overtop contact rail with guard, and this close fitting guard can be purchased on the market made up of impregnated insulating material in sectional lengths which fit the rail exactly and require no supporting straps or brackets. The labor of installing or repairing such guard is, therefore, reduced to a minimum. Such construction has been in satisfactory use for quite a number of years on the New York Central electrification in New York City, also on the Philadelphia Rapid Transit System. Other installations are New York State Railways, Michigan Central Railroad, and the Central California Traction Company, as well as several industrial plants.

Blocking Free Passage of Switchmen or Other Employees Through the Yard.

The type of third rail construction described above makes it very feasible to step over the rail without hazard of shock and without any strenuous effort. Also in crossing the rail there is no danger in actually stepping on the guard which will easily support just as much weight as the rail itself. At any point where it is desirable to do so a gap of approximately 40 feet can be left in the rail without interfering in any way with operation. Thus at road crossings there will be no difficulty, and at an other necessary points such gaps can be allowed. Where two or more tracks run parallel the conductors' rails are located toward the inside of these tracks, so as to leave the outside area free of obstructions to the switchmen and brakemen. With electric operation the locomotive has operating control equipment on each side of the engineer's cab so that he can use either side of the locomotive as desired.

Methods of Crossing Frogs and Switches.

On a general first glance at a steel plant railroad yard one's first opinion is that on account of the complicated track system with numerous switches and crossovers, third rail operation is not practical. However, one only needs to study the situation to a slight extent to overcome these doubts. On many furnace trestle electrified tracks we have solved these difficulties and can easily improve even on such systems, as there are considerable difficulties to contend with there, due to spillage of all kinds of raw materials and scrap down over the tracks, which would not be the case in general yard work. By using four collector shoes, one at each corner of an electric locomotive, and by the use of the side approach conductor rail fitting at switches, it is entirely possible to keep current on the locomotive, even at most difficult track positions, and where gaps must necessarily occur in the conductor rail it is only a matter of getting the proper distance between collector shoes to solve the problem.

For the purpose of making a comparison between steam and electric operation on any particular proposition it is very necessary for accurate results to secure a service data test on one or more of the steam locomotives to be replaced in each class of service. For conducting this test the locomotive is equipped with an electric revolution counter for determining the speed and the distance travelled for any movement. The time is taken with a stop watch, the weights of the cars obtained from the freight records, and a log is kept as follows:

The revolution counter is read and recorded, and as the locomotive starts to move the time is taken, together with the trailing load, until the locomotive is stopped. These values are recorded opposite the counter readings. A new counter reading is not taken until the load is changed, by either dropping or taking on cars. Only the seconds in motion are recorded. If locomotive is stopped for switches, etc., the time it is standing still is deducted from the total time of the move. When the load is changed, this constitutes a new shift and counter is read, and recorded under shift No. 2. The new load and time of the new shift is termed a light shift or running light move. The same record is kept of these moves as of loaded shifts. In keeping this log for a day the total work done by the locomotive for that day can be determined in terms of ton miles. The coal consumed per day is taken from the coal records so that pounds of coal per ton mile can be obtained. In order to arrive at a more reliable average day's work, three tests are made and their averages taken as a normal day's work on each particular application.

The following sample table gives data on a steel mill yard locomotive in typical service of handling incoming and outgoing freight. This work is of a variable nature as cars are spotted and collected all over the yard:

This table shows that the heaviest trailing load handled during the three days was 1,330.5 tons, while most of the work consisted of considerably lighter shifts. The number of shifts per day is 88, while the per cent of time idle, lost in throwing switches, and making couplings, is only 40 per cent of total time. From comparison with other tests, it has been found that a locomotive working its maximum all day will vary its per cent time lost inversely with its length of shift. The average length of shift on this work was 1,682 feet. With this length of shift and size of locomotive, 40 per cent time lost represents a full day's work or as much as can be expected from locomotive so far as movement is concerned. Since the average load was only 199 tons, the trailing load could have been larger and more work or ton miles could have been accomplished, but the time lost would have remained no less and probably some greater. The total mileage per day averages 26.6 miles, which gives the average speed per shift at 5.1 mph. The trailing ton miles, which represent the effctive work accomplished by the locomotive, were 3,530.4, while the locomotive ton miles or tons miles expended in order to accomplish the effect or trailing ton miles were 3,064. The locomotive ton miles represent 46.5 per cent of the gross or total ton miles. As the locomotive ton miles are ineffctive ton miles, the shifting may be said to be only 53.5 per cent efficient. The tender ton miles average 1,010.3 ton miles and are the ton miles necessary only to supply fuel to locomotive. Trailing ton miles should be used as a basis for any calculations since this value is the effective work, hence the amount of coal used to accomplish a trailing ton mile was 1,122 pounds.

Incoming and Outgoing Freight—Locomotive No. 26

Weight on drivers, 75 tons. Total weight, 115 tons.

Test No.	1	2	3	Average
Date of test	2/8/21	2/9/21	2/10/21	3 Days
Length of test—hours and minutes	7:11	7:10	7:27	7:16
Time locomotive was in motion	4:12	4:02	4:53	4:21
Time idle and lost coupling	2:59	3:08	3:34	2:55
Per cent time idle and lost in coupling	41.6%	43.8%	34.4%	50%
Number shifts per day	116	70	77	88
Number shifts light per day	14	14	16	15
Average length of shift—feet	1,180	1,925	1,940	1,682
Average speed per shift in motion	5.1	4.9	5.2	5.1
Maximum average speed—M. P. H.	10.6	9.4	10.6	...
Average weight trailing load	143.3	180.5	273.0	198.9
Average weight of loaded train	258.3	295.5	388.0	313.9
Per cent locomotive weight to total train weight	44.6%	39.0%	29.7%	36.7%
Maximum trailing load (tons)	481.5	907.95	1,330.5	...
Total distance per test (miles)	25.95	25.48	28.29	26.57
Total distance light (miles)	7.24	8.38	10.63	8.75
Per cent total distance light	27.9%	32.9%	37.6%	32.9%
Trailing tons miles per test	2,681.3	3,088.2	4,821.8	3,530.4
Tender ton miles per test	950.5	949.2	1,131.4	1,010.3
Locomotive ton miles (tender inclusive)	3,008.4	2,930.2	3,253.4	3,064.0
Gross tons miles per test	5,689.7	6,018.4	8,075.2	6,596.0
Pounds coal per test	3,960	3,960	3,960	3,960
Pounds coal per Tr. ton mile	1.477	1.282	.823	1.122
Pounds coal per Gr. ton mile	.696	.658	.591	.615

In order to give some idea as to what results might be secured after electrification the figures below are representative of a case which the writer has had under study for some time past and gives actual steam operation costs averaged over a period of several years against estimated costs with electric operation:

	—Steam—	Electric	
		Battery Locomotives	Straight Electric With Third Rail
Number of locomotives	27	27	23
Investment charges, including shop and service facilities, converting apparatus, transmission and contact systems	$850,000.00	$1,220,000.00	$1,376,000.00
Fixed charges per annum	99,300.00	105,300.00	164,800.00
Locomotive depreciation	20,400.00	163,400.00	23,700.00
Fuel or power	116,100.00	28,000.00	18,900.00
Repairs	140,700.00	36,000.00	28,800.00
Operating labor	147,500.00	89,500.00	89,500.00
Station service including miscellaneous operating material	43,000.00	16,000.00	9,400.00
Totals	$567,000.00	$ 438,200.00	$ 335,100.00
Annual saving over steam		$ 128,800.00	$ 231,900.00
Per cent return on investment in addition to normal interest included in fixed charges		10.5%	16.9%

This proposition covers a steel plant railroad yard having a total trackage of 57 miles of single track. There are a total of 27 steam locomotives ranging in size from 75 tons down to 25 tons, and it is assumed that 27 battery locomotives with extra battery units, or 23 straight electric locomotives, using third rail would be required to do the same work. For standardization purposes and flexibility of operation it is assumed that electric locomotives would either be 40-ton or 80-ton units; each of the latter being made up of two of the 40-ton machines. This would mean a total of 37 of the 40-ton battery locomotives or 33 of the 40-ton straight locomotives to be considered. The figures given under electrification for investment charges really represent the net cost of this work after an allowance has been made for the salvage value of the steam locomotives displaced.

These figures really show only part of the saving that can be made by electrification. After the yard is electrified (with third rail system) the next step is to equip the locomotive cranes for motor operation and these machines could work in any part of the yard through the full 24 hours of the day if so desired. The greatest item of saving in this case shows up in the additional amount of work which can be secured from these units, for with steam operation present experience has shown that a general average of 50 per cent of the time is lost due to the cranes having to drop their work and go for fuel or water. In some cases it is true that these items can be secured without any great movement, and in other cases many hours are lost for the same purpose, but in either event it is true that the cranes cannot continue with their work while taking on these requirements. It is rather hard to figure just what saving can be effected without making an extensive investigation over quite a period of time, but for the case cited it is estimated that $70,000.00 annually would be conservative for an average of ten cranes in operation. This would bring the annual saving in favor of electrification up to over $300,000.00 cutting the cost over the present method of operation by almost one-half.

It would appear, therefore, that the general subject of electrification of the steel plant railroad is one which merits our investigations and study, and the writer predicts that the electric motor will displace the steam engine on our transportation system just the same as it has in our rolling mills.

Electric Drive for Small Automatic Self-Dumping Skip Hoists

Field of Usefulness of This Type Hoist Could Be Extended if Their Limitations Were Studied and Means of Improving Their Characteristics Were Pointed Out from the Standpoint of Power Application.

By R. H. McLAIN and C. B. CONNELY,

SMALL automatic self-dumping skip hoists are generally used for ash removal and coal hoisting in power plants and railway locomotive coal stations, and in handling free-flowing bulk material of various kinds. It is believed that their field of usefulness could be further extended if their limitations were studied and means of improving their characteristics were pointed out from the standpoint of power application.

There are three general classes of self-dumping skip hoists. All are equipped with a special bucket which, when drawn into cams at the top, either tilts over and discharges from its top or opens and discharges at the side and bottom, and then rights itself when lowered back into the skip shaft.

Class 1 is the unbalanced skip hoist, and its requirements are:

(a) Power for hoisting a full skip.
(b) Power for hoisting an empty skip.
(c) Brake for lowering an empty skip.
(d) Brake for lowering a full skip.

Class 2 is the counter-weighted skip hoist. The counter-weight may be of any value, but for purposes of this article it will be considered to be equal to 100 per cent of the skip plus 60 per cent of the material in the skip. Its power requirements are:

(a) Power for hoisting a full bucket.
(b) Brake for hoisting an empty bucket.
(c) Power for lowering an empty bucket.
(d) Brake for lowering a full bucket.

Class 3 is the balanced skip hoist. It consists of two dumping skips and skip-ways, one of which is lowering while the other is hoisting. The power requirements are:

(a) Power for hoisting a full skip and lowering an empty skip.
(b) Power for hoisting a full skip and lowering a full skip.
(c) Power for hoisting an empty skip and lowering an empty skip.
(d) Brake for hoisting an empty skip and lowering a full skip.

The rope pulls change while material is being dumped and while some of the weight of the top skip may be resting on the dumping cams, and Figs. 1 to 9 inclusive are plotted to show the motor torque required for Class 3 hoists under conditions (a), (c) and (d), it being assumed that speed is constant. These curves are plotted

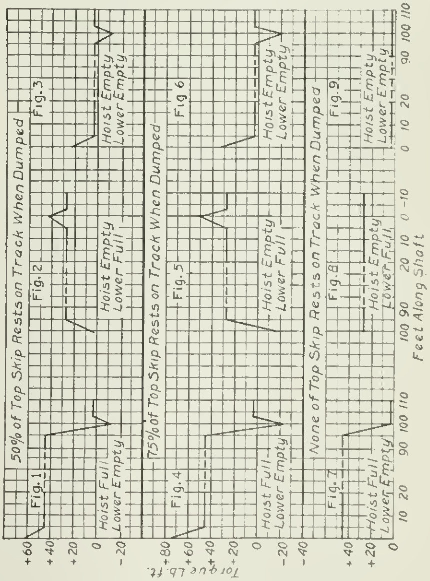

Fig. 1 to 9—Typical rope pulls of balanced hoists expressed in lb.ft. torque at motor shaft.

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with motor torque as ordinates and feet along the skipway as abscissae.

Drums are cylindrical.
Weight of skip 100 per cent.
Weight of material in skip 100 per cent.
Weight of counter-weight (when used) 169 per cent.
Motor speed 900 r.p.m.
Height of hoist 100 feet.
Weight of rope is neglected.

Normal amount of rope drawn in when skip is being pulled into the dumping cams is 5 ft.

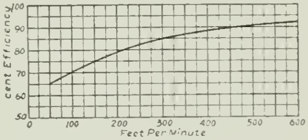

Fig. 10—Theoretical skip hoisting engine efficiency from motor shaft to rope.

The skip or counter-weight when at the bottom is suspended entirely on the rope; also the counter-weight when at the top is suspended entirely on the rope. A variation in this arrangement can easily be made by allowing some of the weight of the skip at the bottom to rest either on a weigh-beam or a cam-shaped track. Such an arrangement can be made to materially improve the duty cycle, especially as regards accuracy of stopping and amount of starting torque. (Figs. 7, 8 and 9, while not plotted to cover this condition accurately, illustrate the nature of the advantage obtained.)

When the skip is in the normal fully dumped position at the top, either 100 per cent, 50 per cent or 25 per cent of the weight of the skip may be suspended from the rope, the remainder resting on the dumping cams. The amount of weight which hangs on the rope depends upon the type of bucket and cams. Distinction will be made between the duty cycles under each of the three conditions. When the skip is drawn three feet of rope travel above the normal position of dumping, 100 per cent of the weight of the skip is suspended from the rope.

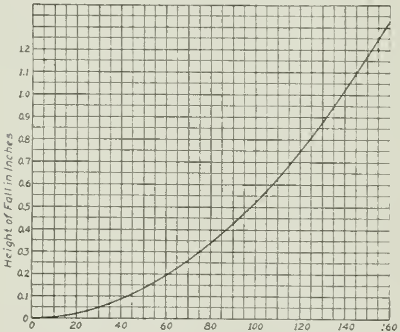

Fig. 11—Speed at which a falling body strikes versus height of fall in inches.

The losses in sheaves and the shaft friction for a skip are taken as 3 per cent of the rope pull produced by that skip in a vertical shaft.

The mechanical efficiency of the hoisting machine between motor pinion and rope is taken as 85 per cent.

An additional set of curves, Figs. 12 and 13, are plotted to show how great is the variation in the point of stopping both at the top and at the bottom when certain of these conditions vary. In this set of curves the variation of the stopping point in feet is plotted as ordinates against the skip speed in feet per minute as abscissae. These variations are caused by the following variations in hoist conditions, which are now used to supersede certain assumptions made above:

The hoist machine efficiency will now be taken as 65 per cent for 50 ft. per minute speed, and will vary up to 85 per cent for 300 ft. per minute skip speed, as shown on Fig. 10.

References to Tables I and II will show that speeds ranging from 95 per cent of synchronism for hoisting to 124 per cent for lowering, and 95 per cent for hoisting to 113 per cent for lowering, were used to cover variations due to voltage and load conditions and to the class of motor considered.

A wound rotor polyphase induction motor with the armature short circuited and with normal voltage has a full load speed 95 per cent of no load speed.

It takes one-fifth of a second for a friction brake to begin actual retardation after a stop limit switch has tripped. This assumption makes allowance for the time required to open the circuit to a contactor plus the time for it to drop open, plus the time for the circuit through the contactor to be broken, plus the time required for the brake core to move from the released to the applied position.

The acceleration of the armature and all other moving parts is assumed to require during one second 100 per cent of the torque required to hoist normal load at normal speed up the straight part of the shaft.

Voltage will be assumed to be 105 per cent maximum and 90 per cent minimum, and for each condition the particular voltage value will be chosen which tends to make the widest variation in speed. This will mean that the motor speed varies from 95 per cent to 124 per cent of synchronism.

The torque produced by the friction brake will be assumed to be somewhere between 125 per cent and 150 per cent. The value which produces the widest variation in landing accuracy will be used.

From Figs. 12 and 13 it is easy to determine the cage speed at which a hoist can be operated for any desired accuracy of landing. But these curves, as shown by foregoing assumptions, picture the conditions of what might be called an ordinary installation where no refinements were used to improve the accuracy of the landing.

The Tables I and II, which refer to Figs. 12 and 13, indicate that much greater accuracy of landing may be obtained by adopting improved methods, as follows:

1. Use a heavier solenoid brake whose maximum retarding torque is 200 per cent of torque required to hoist full load at full speed and minimum retarding torque is 166 per cent.

2. Provide means in the control apparatus which will eliminate entirely the time interval between the shutting off of power from the motor and the beginning of retarding torque by the brake.

3. Use a motor which has a speed ratio of 2:1, that is, it can be slowed down from a maximum speed to one-half maximum speed before the final stop is made. Such a motor would have approximately 20 per cent more

flywheel effect in its armature than would a single speed motor.

4. Use a slip ring induction motor in which all resistance is short circuited while hoisting, thus insuring a range in motor speed between 96 per cent and 114 per cent.

Tables I and II indicate by percentage the relative accuracy of these various expedients. The conditions shown by Fig. 12 are taken as 100 per cent for Table I and those shown by 13 are taken as 100 per cent for Table II. For example: In Fig. 12, the variation in stopping for a skip whose full load normal speed is 300 ft .per minute will be 6.9 ft. Now, by referring to Table I, it will be seen that this condition is considered as 100 per cent, and if the control is arranged to take the lag out of the brake, this variation will be 47.7 per cent of 6.9 ft., or 3.3 ft. If this time element is taken out of the setting of the solenoid brake, and if the brake is increased so that its retarding torque varies between 166 per cent and 200 per cent of normal torque, the variation now becomes 25.3 per cent of 6.9 ft., or 1.74 ft. If a still further improvement is made by using a 2.1 adjustable speed motor having a small slip, and the large brake is still used, the variation will be 6.2 per cent of 6.9 ft., or 0.43 ft. In other words, by introducing several refinements a very high degree of accuracy can be obtained.

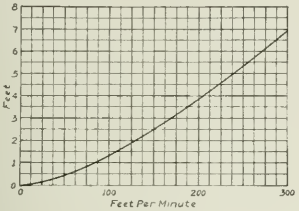

Fig. 12—Variation in stopping in feet versus normal hoisting speed under following conditions.

As indicated above, one method of improving the accuracy of landing is the use of a 2:1 adjustable speed motor which is slowed down to a creeping speed for approaching the landing point.

There are three other conditions besides accuracy of stopping which will determine the value of this creeping speed, viz.: first, the speed at which the skip may be permitted to enter the dumping horns because of strains in the structure when the vertical velocity of the skip is changed to horizontal velocity; second, the speed at which material may be permitted to spill as determined by its disposition in the receptacle into which it falls; third, the speed at which the skip may strike the scale beam at the bottom when such a beam is used. No attempt will be made in this paper to prescribe these limits because they depend on conditions other than power drive, but Fig. 11 is submitted as an aid in judging the speed. The accuracy required for landing is most frequently the cause of speed limitation.

Don't use series wound direct-current motors except on Class I hoist.

Don't use compound-wound direct-current motors except on Class I hoist, unless the series field is short circuited by the starting controller.

Don't insert resistance in the armature circuit of a direct-current motor or an alternating current motor and expect this to improve the accuracy of landing. Under normal conditions it may diminish the speed at which the skip enters the dumping horns, but it increases the variation in stopping accuracy and under abnormal conditions of load, such as hoisting an empty skip and lowering a full skip, it increases the speed at which the skip enters the dumping horns. The only sure method with cylindrical drums* of getting a dependable decrease in speed for dumping and landing purposes is to use dynamic braking or shunt field control in the case of d. c. motors, or multi-speed windings in the case of a. c. motors.

TABLE I
For Class 3 Skips

When hoisting an empty bucket and lowering a loaded one the per cent variation from the stopping distance in Fig. 12 is given below:

Motor Speed Range						
2:1			1:1			Pct. Wt. of Skip on Rails in Dumping.
Variation from Snych.						
95-113 Per Cent		95-124 Per Cent	95-124 Per Cent			
Brake Per Cent						
150-125	200-166	150-125	150-125	200-166		
Percentage Variation from Fig. 12						
		18	72.		A	
9.43			41.	22.6	B	5
		30	100		A	
17.	6.2		47.7	25.3	B	50
		31	102.		A	
31.5	7.73		53.3	28.1	B	75

A indicates variation allowing 0.2 seconds after power shut off before brake applies.

B indicates variation when braking commences instantly after power cut off.

TABLE II
For Class 3 Skips

When hoisting an empty bucket and lowering an empty one the per cent variation from the stopping distance in Fig. 13 is given below:

Motor speed range	2:1	1·1			Pct. Wt. of Skip on Rails in Dumping.
Variation from Synch.........	95-124 Per Cent	95-124 Per Cent			
Brake per cent..	150-125	150-125	200-166		
	9.76	54.7		A	
		41.3	22.7	B	0
	9.88	100.		A	
				B	50
	24.3	113		A	75

A indicates variation allowing 0.2 seconds after power shut off before brake applies.

B indicates variation when braking commences instantly after power cut off.

In order to render these skip hoists automatic in action it is necessary to use full magnetic control, and along with this should be provided overload protection. Sometimes no voltage protection is also necessary, but in other cases it is perfectly proper for the hoist to resume operation as soon as power is returned. In the case of a.c. motors protection should be provided against an accidental reversal of the phase rotation in the power supply. This can be done either by the use of a reverse-phase relay or by special arrangement and connection of limit switches. Some trouble may be encountered from a reversal of incoming power, as the skip may start down with a wrong condition of load and this may cause trouble, or it might injure someone who had every reason to believe that the skip was going to start in the normal direction and had placed himself in a dangerous position. A phase reversal relay will protect against either of these troubles. Another trouble is that the usual method of connecting limit switches protects against over-travel only when the normal up contactor will stop the cage from going in the up direction, but under conditions of phase reversal the up contactor would not control the motion of the up direction. Consequently an elaborate arrangement of limit switches or a phase reversal relay is required to protect against such an emergency. A slack cable switch for stopping the hoist, should a cable become slack around the drum indicating that it was broken or that a skip had been obstructed in the shaft, would protect against trouble.

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*Conical drums can be made to decrease the ship speed even when motor speed is constant.

Automatic control may be made to perform any of the following functions:

(a) An attendant starts the skip from the bottom and it is hoisted to the top where it is automatically dumped and stopped. It does not move again until an attendant starts it, and it goes through this cycle each time an attendant starts it. Such an equipment requires a push button for starting up, a push button for starting down, a stop switch, and the necessary limit switches for slowing down and stopping at each end of travel.

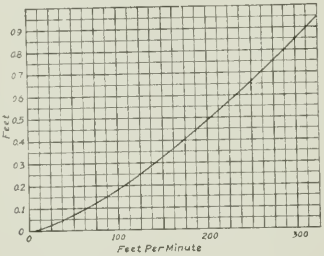

Fig. 13—Variation in stopping in feet versus normal hoisting speed under following conditions.

(b) On Class 1 and Class 2 hoists, it is often advantageous for the operator to start the skip from the bottom and for the skip to make a round trip before the operator is again required to give it attention. Such a controller requires a push button for starting up, a push button for starting down (to be used only in cases of emergency or try-out), a stop switch, a time element relay for holding the motor at standstill for approximately five seconds at the top while the skip is being dumped, and limit switches for slowing down and stopping at each end of travel.

(c) On all classes of hoists it is sometimes advantageous to have a means of starting the skips into operation and having them run continuously without further attention, with approximately five-second intervals at each end of travel for loading and unloading. Such a controller would require a starting up push button, a starting down push button, a stop switch, necessary time element relays and limit switches for slowing down and stopping at each end of travel.

(d) Class 1 and Class 2 hoists sometimes require a five-second interval for unloading at the top, and an automatic switch connected with a scale beam for starting the skip at the bottom. Such a hoist will run continuously when once started and will automatically dump and reverse at the top, and will remain at the bottom on a scale beam until a pre-determined weight of material is spilled into it, whereupon it automatically is hoisted to the top. Such a controller requires a starting up push button, a starting down push button, a stop switch, time element relay, master switch operated by a scale beam, and the necessary limit switches for slowing down and stopping at the end of travel. It is also necessary that there be a certain amount of slack rope leading to the bottom skip when it first rests on the scale beam at the bottom of each shaft—one scale beam starts one of the skips up when loaded, and the other scale beam starts the other skip up. In addition to this, a time element relay might be inserted to hold the motor at standstill not only while the scale beam is operating, but for a predetermined time of about five seconds so as to make sure that the top skip has been fully emptied. Such a controller would require a starting up push button, a starting down push button, a stop switch, two master switches which are operated from scale beams, necessary time element relays if desired, and limit switches for slowing down and stopping at each end of travel.

A necessary part of all of the above control apparatus is that the motor be equipped with a solenoid brake; but under one special condition it is possible to operate a skip hoist without a solenoid brake, and this on a Class 1 hoist, although this is not always to be recommended on account of other disadvantages; for instance a brake of some kind may be needed when repairs are made. A series wound d.c. motor can be used for hoisting, and if the hoisting speed is such that the material is fully dumped at the time the skip reaches the top of travel, the motor can be allowed to reverse immediately and descend by dynamic braking, using a normally closed contactor. Stopping at the bottom can be obtained by decreasing the dynamic braking resistance and then allowing the skip to settle at very slow speed onto a positive foundation at the bottom. When shunt wound direct-current brakes are used, a centrifugal switch or some protective relays are needed to prevent the current regenerated by the motor from sustaining the brake in case power fails. A sustained brake would allow the motor to overspeed.

STRENGTH OF REFRACTORIES AT HIGH TEMPERATURES.

The arrangement for testing refractory materials within a furnace at high temperatures which E. Rengade and E. Desvignes described a few weeks ago in a paper presented to the Paris Academie ("Comptes Rendus," vol. 119, pages 134 to 137) is that of a machine for determining a Brinell hardness. Instead of the ball of Brinell, however, they use a cone of an angle of 90 deg., as introduced by Ludwick. The furnace is of the Rosenhain graphite ring type. The specimen is roughly made of cylindrical shape, about 30 mm. in diameter; the shape does not matter provided the top and bottom are plane. On the top rests the cone; it is mounted in a graphite ring so attached to a jointed rod that the rod can be withdrawn to take pyrometer observations, and can afterwards be lowered on to the specimen and loaded with a weight of 10 kg. This is done when the temperature inside the furnace has become constant; the load is then put on for about 10 minutes, after which the temperature is redetermined. The curves obtained with different materials, high or low in silica or alumina, are regular and much of the same type showing that a gradual softening sets in, at temperatures which in the cases mentioned ranged from 1,150 deg. up to 1,270 deg. C., and which increased as the temperature was raised to 1,500 deg. C. maximum.

Damascene Steel and It's Origin

This Steel Is Receiving the Attention of All Those Interested in Tool Steels—Experiments on This Steel, Interrupted by the War, Now to Be Resumed.

By COL. N. T. BELAIEW, C. B.*

PART II

IN THE first paper on damascene steel[1], presented to* the Institute in 1918 by the author, he described the general properties and structure of damascene steel, and pointed out the great claims it had to the attention of all interested in tool steel. The object of the present paper is to substantiate that statement, more especially as regards high-speed steels. In the author's opinion a marked analogy exists in the structure and in some of the properties of high-speed and damascene steels, and a comparative study of both might therefore prove beneficial in explaining certain properties and in opening new vistas.

2. Damascene steel belongs to the hypereutectoid series of carbon steels. As mentioned in the author's previous paper, the average carbon content of typical damascene articles should be about 1.5 per cent. That amount of carbon, however, does not exist as such, but as a definite chemical compound, Fe_3C, or cementite. Introducing the respective weights of iron and carbon:

$$(3 \times 56) \text{ iron} + 12 \text{ carbon} = 180\ Fe_3C,$$

we arrive at the result, that one part of carbon produces $\frac{180}{12}$ or 15 parts of cementite. 1.5 per cent of carbon in steel represents, therefore, 22.5 per cent. of cementite, which, from the practical point of view, is a very large amount. About one-half of this amount (11.5 per cent) forms the excess, or free cementite. The other 11 per cent of cementite with a corresponding amount of ferrite is used up in building up "pearlite."

The free cementite is coarser than the eutectoid cementite, its spreoidisation is correspondingly more difficult and necessitates repeated hammering and heating. The greatest care must be taken to break the large cementite needles into smaller particles and afterwards to cause their complete spheroidisation.

The Indian damascene blades, examined in Petrograd by the author, showed a perfect balling up, as may be seen froms Figs. 3 and 4 (Plates XLII and XLIII) of his previous paper. The completeness of the spheroidising process may be further illustrated by Fig. 1 (Plate XLI), which shows at a magnification of 1000 a section of an Indian blade, photogaphed in the author's London laboratory by Captain B. Brandt. The larger particles shown in the section are those of "free" cementite, the smaller ones are eutectoid cementites. Both groups are thoroughly spheroidised.

Figs. 1 and 2 (Plates XLI and XLII) of the author's first paper also show what a large amount of mechanical treatment (as shown by the macrostructure of the blade) was required to attain such complete spheroidisation. The macrostructure shows also that the cementite veins run closed up to the edge, and that therefore the oriental maker must have relied most upon securing the best cutting properties of the cementite particles.

3. High-speed steel is a tool steel which possesses the property of maintaining its hardness at a relatively high temperature. This property is secured in a large degree by adding tungsten and chromium, usually 16 to 20 per cent of the former and from 3 to 5 per cent of the latter; the carbon content is generally not over 0.75 per cent; up to 1 per cent of vanadium is also added.

This steel belongs to the cementitic (carbide) series; its structure (Fig 1, Plate I), when annealed, presents a striking similarity to the structure of damascene steel (see, for instance, Fig. 336, p. 356, of Sauveur's "Metallography"). Spheroidised carbide particles are embedded into a sorbitic matrix. To produce "high-speed hardness" such steel has to be heated to a very high temperature, and then quickly cooled. A certain amount of carbide remains undissolved, even after rapid cooling from temperatures close to the melting point (see, for instance, Figs. 334 and 342 (Yatsevitch) of Sauveur's "Metallography"). There are even indications that a moderate amount of free carbide appears to increase the cutting properties of the tool.

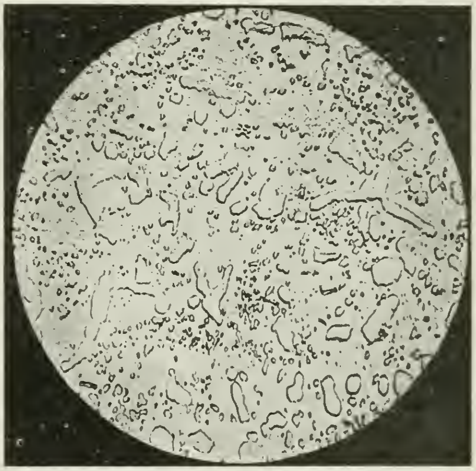

Fig. 1—An Indian blade from the author's collection. Globules of spherodized cementite embedded in a sorbitic matrix ×1000.

The actual makers of high-speed steel, however, emphasize that the making of the high-speed structure begins under the hammer; that during this operation "the massive carbides and tungstides present in the ingot are broken down and uniformly distributed throughout the billet;"[1] and further, that "to accomplish this the reduction in area must be sufficient." Therefore, ingots are first hammered into billets, the billets are again slowly heated and then hammered for a second time ("cogged") —all this "mechanical treatment" by properly breaking and evenly distributing the carbides (and tungstides) throughout the steel.

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*Paper presented before the British Iron and Steel Institute, September 5-6, 1921.

[1] Colonel Belaiew, "Damascene Steel," *Journal of the Iron and Steel Institute,* 1918, No. I, p. 417.

[2] "The Manufacture of High-Speed Steel in the Electric Furnace," by Rog. C. McKenna, President of the Vanadium-Alloy Steel Corporation. *Transactions of the American Electrochemical Society,* vol. xxxvii, p. 322.

4. If we proceed now to compare not only the photomicrographs, but also the two processes—the "high-speed hardness" and the "damascene" process, we see how similar they are.

Both start with a cementitic steel; both require the greatest care in breaking and evenly distributing the carbides under the hammer; in both cases the amount of mechanical work spent on a given article is very large, but however large it is considered indispensable before a suitable heat treatment may be effected. In both cases the structure of carbides is spherolitic, whilst the matrix, after the heat treatment, is martensitic. In both cases also the cutting properties of the edge are related not only to the matrix, but to the carbides as well. The author is even inclined to think that the properties and the distribution of the carbides play a more considerable rol ethan the matrix. On this ground may be explained the reason why, on the one hand,, such diversities of opinion exist as to the structure of the matrix in high-speed steels, whilst, on the other, neither the old eastern makers nor Anossow seemed to attach any real importance to the tempering of damascene steel. The author's studies in this field have led him to the belief that whilst being very strict as regards the hammering temperatures, nobody who has really busied himself with damascene steel cared much as to its subsequent heat treatments.

5. There are a few conclusions which can be drawn from these preliminary remarks:

First, there is the question of spheroidisation of the carbides. In damascene steel the degree of spheroidisation is always very high. That spheroidisation, however, was not an end in itself for the ancient maker, but was attained, so to say, incidentally during the numerous cautious forgings and heatings, when the greatest ductility was sought and obtained.

In high-speed steels that spheroidisation is also attained, but it seems to the author that insufficient stress has been laid on that point, either by the high-speed steel maker, or user. He believes that a scientific application of the spheroidising process would help to improve the qualities of high-speed steel. He thinks, further, that another inference from the damascene process might be drawn, namely, the proper study of the macrostructure. An oriental maker would never manufacture a steel article without having satisfied himself, by studying the watering, that the distribution of the carbides is the best possible and quite in accordance with the shape and properties of the article. Neither would he find a buyer ready to accept a sword or tool without a proper "metallographic" examination of it as a whole (towards that end the splendid oriental watering lent itself so well). The author therefore believes that a proper examination of the "watering" of high-speed steel, either in billets or in the finished article, will prove useful.

As to the damascene steels, whilst not ready to place them in the category of high-speed steels, the author is, however, inclined to think that a certain "high-speed harness" which he noticed during his experiments on damascene steel (interrupted by the war) might not prove quite accidental, but useful for further investigation.

TORONTO PLANT NOW COMPLETED.

The Toronto plant of the Follansbee Brothers Sheet and Tin Plate Company which is now almost ready for operation, stands unchallenged the last word in the steel industry; the colest, best equipped and most convenient and systematically arranged plant of its kind in the world.

Cost About $5,000,000.

Stretching for a quarter of a mile along the river, the new plant gives a splendid impression. The big plant is modern in every respect and with its great power plant with three stacks each towering 175 feet in height, and with all shops and other separate buildings of light brick, the mill gives to the outsider an impression of progressiveness on the part of the operators.

Open Coal Mines.

When the company started building its new plant the securing of fuel and electric current was considered an outside matter. With coal lands in the vicinity and a great power company operating in the district it was not then indicated that the company would be independent of such services. However in the past year and a half a coal mine has been developed and a power plant second to none in the state of Ohio erected on the river's edge.

Coal is then automatically brought to the entrance of the mill where it is in turn powdered. It is then used for feeding eight Hughes automatic gas producers. Each producer consumes four tons of coal per hour.

The Power House.

The gigantic power house has a capacity of 7,500 kw. There are three batteries of two boilers each having 3,600 hp. All boilers are equipped with Westinghouse stokers, forced draft soot blowers and automatic skip hoists for ashes and soot.

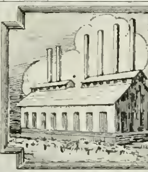
Open Hearth.

Modern open hearths have been built in addition to the complete bar mill practically equipped. The bar mill is similar to the one which the Company now operates at Follansbee. There are ten hot mills. The sheet mills are larger than those at Follansbee. Four being 50", three 44" and three 40".

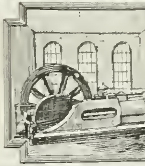
New Annealing Process.

Among the features of the Toronto plant is the annealing equipment. There are two big Dressler kilns working a continuous process of annealing. One kiln is 350 feet in length and the other 320 feet. This represents the most modern annealing plant known to the steel world. In addition to this equipment there is a carpenter shop, store room, and other essential buildings.

When completed and working in full capacity, the plant will employ about one thousand workmen. It is the intention of the company to start operations about October 1st.



STEAM POWER DEPARTMENT



Boiler Water Treatment Plants

The Various Methods in Use for Treating Bad Water—This Is Accomplished by Chemical Means, Mechanical Means or by Thermal Treatment.

By ROBERT JUNE, M. E.

PART II

IN OUR preceding article we dealt with the nature of the various impurities in boiler feed water, and the operating troubles resulting from them. We have now to consider the various methods in use of treating bad water.

According to our previous outline, the neutralization or elimination of impurities in feed water may be effected by one or more of the following methods:

- I—By chemical means.
  - (a) Boiler compounds.
  - (b) Water softening plants.
- II—By mechanical means.
  - (a) Tube cleaners.
  - (b) Blow off.
  - (c) Filter plants.
- III—By thermal treatment.
  - (a) Feed water heaters.
  - (b) Distillation plants.

Boiler Compounds.

There are a number of boiler compounds in use, but the base of most of these is carbonate of soda, to which caustic soda is sometimes added and occasionally phosphate of soda. In addition materials containing tannin and starch are frequently added, with the object of coating the particles of precipitated matter so as to prevent their corrosion.

The use of boiler compounds is sometimes condemned as thoroughly bad practice, the following contentions being made: That mechanical difficulties prevent the maintenance of a proper ratio between the amount of compound used and the volume of water; that it is very difficult to control the treatment to take care of the changing analysis of the water; that adequate boiler compound treatment is very expensive; that compounds necessitate frequently blowing down the boiler to prevent an accumulation of sludge and sodium salts, which cause foaming, and that, moreover, blowing down must frequently be supplemented by washing out and occasionally cutting out the boiler completely to remove foreign matter.

Despite these criticisms, boiler compounds still find favor with many practical men, particularly in small boiler plants. When it comes to compounds, a great deal of care and attention must be paid to their selection and use. A great deal depends upon the attitude of the compound manufacturer. If he is willing to sit down and thresh out your problem with you, you may receive satisfactory service at a cost that is not prohibitive.

It is all simply a matter of relation of costs to the results obtained. While there are some compounds on the market which are worthless, and some manufacturers who offer cure-alls and do not give satisfactory service, there are other compounds which are reasonably satisfactory and do not involve a large plant investment. Though the weight of evidence is very much against the indiscriminate use of compounds, the fact remains that they are in satisfactory use in many small plants.

Graphite.

Graphite has no retarding influence on the formation of scale, but it tends to prevent the scale from adhering firmly to the metal. The particles of graphite simply work through the minute fissures existing in the old scale and gradually penetrate between the scale and the metal. The scale thus loosened may be knocked off or removed with regular cleaning tools with little trouble.

Before starting the use of graphite, the boiler must first be thoroughly turbined. Once removed, the scale will not adhere firmly to the metal again as long as the gaphite treatment is continued. The graphite also becomes intermixed with new scale as it forms, rendering it soft and friable. With graphite, as with boiler compounds, any boiler using bad water should be blown down a gauge or two every few hours to remove sludge.

Kerosene.

Good results in softening scale are sometimes secured through the use of kerosene and other refined petroleum oils. This treatment changes the deposits of lime from a hard scale to a friable material which may be easily removed. If the treatment is to be effective, kerosene should be introduced after the boiler is emptied and washed, and the refilling should be effected from the bottom. If kerosene is fed into the boiler with the feed it may form a non-conducting film over the heating surface.

Zinc.

While zinc is often introduced into boilers to prevent corrosion and scale formation, it does not as a matter of fact always accomplish this purpose, and it may even aggravate the trouble. The action of zinc is electrolytic, the theory being that a continuous flow of hydrogen is generated over the whole extent of the wet surface of the boiler. It is supposed that the continuous formation of the bubbles of hydrogen insulates the surface of the metal from the scale forming substances. If there is a little of the scale forming element it is precipitated and reduced to mud; if there is considerable, a formed scale is produced which, however, does not adhere tightly to the surface of the metal and is consequently readily removed.

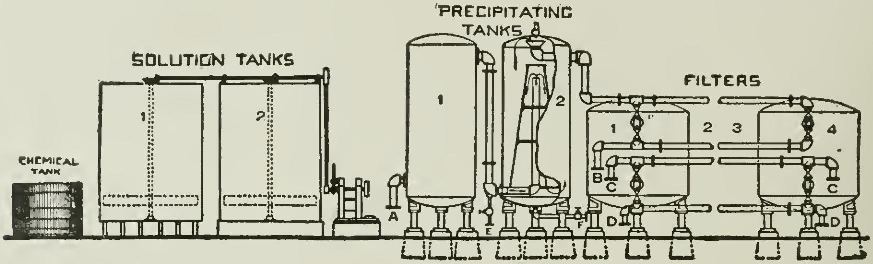


Fig. 1—The Scaife System.

The zinc is introduced in the boiler where it is suspended in the water in the shape of blocks, slabs or shavings, in a perforated container. In marine practice, where zinc is in much greater use than in stationary boilers, it is usual to find zinc slabs 12"x6"x1½" in use. One square inch of zinc surface is ordinarily supposed to be sufficient for 50 lbs. of water in the boiler, although as a matter of fact the quantity of zinc used should be in proportion to the hardness of the water. The British admiralty, who are advocates of zinc, recommend renewing of the slabs when their disintegration reaches a depth of ¼".

Boiler Metal Treatment.

A treatment which has in recent years come into quite wide use consists in the application of Perolin. This is a blue viscous non-volatile mineral liquid, which possesses the characteristic of an exceedingly high coefficient of expansion. The liquid is injected into the boiler in small daily doses. It penetrates the pores and crevices in the scale and comes into direct contact with the metal, where, like graphite, it works its way along the steel, eventually forming an insulating coating between the scale and the tubes. The high coefficient of expansion tends, whenever the boiler is cut in, to loosen any scale which has formed.

Advantages and Disadvantages of Compounds and Metal Treatment.

Compounds and metal treatment of the various sorts described above possess the advantage of not requiring an initial plant investment and of lending themselves very readily to experimentation. In case a given compound or treatment does not work, it may be modified, or another treatment may be tried. The operating costs are also less per gallon of water treated than where special treatment is installed.

The serious disadvantages of compounds and metal treatment are that under favorable conditions all that the most effective of these methods can do is to change the nature of the scale forming materal from one which will be precipitated to one which will be carried in suspension. Frequent blowing off is at all times necessary with consequent heat losses, and as the accumulation of sludge can never be entirely removed while blowing off, so that the boiler is frequently cut in for washing. This puts the boiler out of commission and entails a loss on the investment in the boiler whenever an extra steam generator must be provided to take the place of those cut out for washing. Frequent cutting in and out of the boiler itself is an expensive operation. Taking everything into consideration, compounds and metal treatment are to be recommended for use primarily in small plants. In large plants, and in particular where steam must be continuously generated, we must turn to a method of treating the water before it enters the boiler.

Water Softening and Purifying Plants.

The treatment of water outside of the boiler through the medium of water softening plants is accomplished by either one of two processes, known as the intermittent and the continuous.

Cold process plants are used primarily where water is required in very large quantities. Hot process plants are commonly used where exhaust steam is available for heating the water.

With the continuous system, the water to be treated flows to the softener in a continuous stream, while with the intermittent system it is treated in batches. Successful treatment in either case requires the proper proportioning of water and chemicals, thorough mixing and agitation, and the allowance of sufficient time for the reaction to take place so that all of the sludge may be removed from the water.

Lime and soda are the principal ingredients used in these processes, where sulphates of lime and magnesia are contained in the water, together with such quantities of carbonic acid or bicarbonate present as to impair the action of the soda. This is quite a common condition. The sulphates of lime and magnesia are broken down by the soda, and as much lime is added as is required to take up the carbonic acid not absorbed in the soda reaction.

Before dealing with the apparatus, it may be well to describe simply the chemical tests of the treated water which will enable us to interpret intelligently the results being obtained. Alkalinity, hardness and causticity, should, when the water is properly treated, be in the approximate relation of six, five and four. The use of too much lime will result in causticity being nearly equal to alkalinity. The use of too little lime will result in a causticity amounting to only about half the alkalinity. If too much soda is used, hardness, which should not be more than two points less than alkalinity, will be decreased below this amount, and the alkalinity correspondingly increased. Too little soda means an increase in hardness and a decrease in alkalinity. The tests are as follows:

Alkalinity—Provide a standard solution of sulphuric acid. Put sufficient methyl orange in 50 cc. of the water being tested to color it. Measure out a quantity of the acid solution and put it in a drop at a time. As the acid solution is added the mixture will begin to turn red. Shake the mixture and the redness will tend to disappear. Put in more acid and continue to shake. As the critical point is approached the red will disappear more slowly. 1/10 cc. of the acid solution is equivalent to one degree of alkalinity.

Causticity—Use the same standard solution of sulphuric acid. To 50 cc. of the treated water add one drop of phenolphthalein dissolved in alcohol. This is to give the water a pinkish color. Put in a drop at a time of the acid solution, shaking after each addition. The critical point is reached when the color entirely disappears. 1/10 cc. of acid solution is equivalent to one degree of causticity.

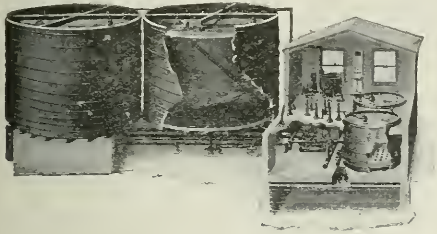


Fig. 2—The We-Fu-Go System.

Hardness—Procure a standard soap solution. To 100 cc. of the water to be treated, add 1 cc. of the soap solution, and shake thoroughly. If the soap bubbles disappear, add another cc. of the soap solution. Enough of the soap solution must be added to make a permanent lather or foam from which the soap bubbles will not disappear after the shaking is discontinued.

To determine the excess of lime, add a small amount of silver nitrate to the treated water. If a milky white solution is formed the lime is not in excess. If the mixture turns brown there is too much lime

The Scaife System.

In the Scaife system, which is a continuous one, the feed water first enters the heater, where it is brought to a temperature of 200 to 210 deg. F. As a portion of the CO_2 is driven off by the heat, carbonates of lime and magnesium are precipitated and deposited in removable pans inside the heater.

The system consists of a number of precipitating tanks with one or more pressure filters, all built to operate under the boiler pressure, and the necessary solution tanks, pumps and controlling devices. The precipitating tanks may be either horizontal or vertical, depending upon the space available. The solution tanks hold sufficient quantity of chemicals to operate the plant from eight to twelve hours. The small pumps deliver this solution to the precipitating tanks, which are so constructed that the water is kept constantly moving and the chemicals are intimately and thoroughly mixed. In this manner acids are neutralized and the scale forming substances are changed to insolubles which sink in the form of heavy precipitates to the bottom of the tank, whence they are readily removed. From the precipitating tanks the mixture moves to the filters, where the lighter substances in suspension are effectively removed.

We-Fu-Go System.

The We-Fu-Go is an intermittent process. The system consists essentially of one or more solution tanks from which the chemicals are taken, and one or more settling tanks into which the water to be treated and the chemicals are introduced, and of one or more filters. A thorough mixture of the chemicals and the water in the settling tanks is effected by the use of mechanically operated paddles located near the bottom of the tank. The softened water is taken out of the tank by means of a hinged floating outlet pipe, arranged to rise and fall with the level of the water, so that the water is always drawn from the top, where there is the least amount of sludge. From the settling tanks the water flows by gravity into the filters, which remove all remaining solid matter which has not dropped to the bottom of the settling tank.

From the filter the purified water again flows by gravity into the clear water storage reservoir from which it is pumped to the open heater and thence to the boiler. As a general rule duplicate systems are employed, so that while one tank is being treated and settled, the other is supplying finished water.

It should be understood, of course, that the above descriptions of the Scaife and We-Fu-Go systems are general in nature, as modifications of both of these systems are often made to meet special conditions.

Our next article will deal with the operation and maintenance of the water softening plants described in this article and we will also take up in detail the design, construction and operation of Zeolite plants.

DEVELOPMENT IN INDUSTRIAL EDUCATION.

Although hundreds of industries have experimented with various plans for training their employes, it has remained for the Pennsylvania State College to work out a plan which appears nearer to the ideal than anything yet attempted. The methods adopted by this institution have long since passed the experimental stage and are in operation in a large number of plants in Pennsylvania where it has been demonstrated that an efficiency far beyond that of ordinary class instruction can be obtained.

For ten years a staff of highly trained men in industrial education has been maintained at State College, and large sums of money have been spent in studying methods of conducting apprentice schools and night classes in the industries. This staff, known as the Engineering Extension Division of the College, has personally organized and operated hundreds of classes in some of the best known plants in Pennsylvania, among them being manufacturers of iron and steel, electrical equipment, machines and tools, automobile parts, textiles, and others common to the State. Each such enterprise was accompanied by an intensive study as to the characteristics which entered into its success or failure. The natural result has been that improved methods were continually adopted until it can now be practically assured that a company can inaugurate a general training policy with far more success than is generally believed possible.

PRODUCTION TOPICS

OUTLINE OF A PRACTICAL COURSE IN STEEL-MAKING.

By P. S. Young

In every plant producing steel products there is present a number of employes which, when properly trained and experienced, will become rare executives in their departments. Also, having had practically no experience in other departments of the mill, most of these men will be narrow in their views of other departments of the plant. Now, in spite of this the time will come when these men are in line for promotion to a higher executive position, and the position will have to accept them just as they will have to accept the position. The longer their work has lain in one department, the harder it will be to adjust them to the higher position requiring them, and the more the position will shrink to fit them.

Such being the case, if a selection from this latent ability were to be made, and the selected men thoroughly coached in the various departments, each when placed in a department would have a broader scope of the needs of the other branches of the mill, realizing the relationships of the other departments to their own, what they bless and what they curse, step by step in the unfinished products.

They are far more fit for departmental control and better equipped to handle a number of departments. No friendships or executive meetings among the department heads breaks down the loyalty of a man for his department or his prejudices established on his own troubles. One must have worked in a blast furnace plant to appreciate "cold cores" in an open hearth to understand the trouble with a bad "sticker," in a blooming mill to find sympathy for "green" steel or "washed," in a rod mill to understand "cross-rolled" and "finned" product, or in an electrical department to sympathize with an industrious craneman whose crane has controllor trouble or burns up an armature at the busiest moment.

Now say that this latent ability could be selected at an early stage of its career, and others could be brought into the mill fresh from some good technical school, would these men develop with proper training into the class of ability required? There can be but one answer, which is "yes" provided:

First—The selection is careful, combining good technical education with willingness and ability to work.

Second—The training is actual work and experience covering the essential details of each department.

Third—Proper supervision by the then department head.

Fourth—A contract between the student and the company that he will be taken care of until placed, if he finishes his course successfully; and that he, the student, will give the company a certain period to be agreed upon at the time of taking up the course for them to place him.

Item 1. Careful selection.

a. Technical education with good grades in chemistry, physics and higher mathematics.

b. Graduated at least one year. This is to take away any chance of his following theoretical instead of practical phases of the work on the course.

c. A thorough physical examination to show if the man is fit and sturdy enough for the work which he will have to do.

d. If brought in from outside the plant, one month of work at labor in various parts of the plant to see how easily he is disheartened, and with a written report at the end of that time describing the jobs he has been covering. This report should show his ability in reconstructing difficulties under which he has worked, any better way he could show of doing the work, and testing his memory.

N. B.—During this month the applicants may be kept in a gang or worked singly at labor rate, the first two days for six hours, the next two for seven hours, until they are working ten hours daily. If in a gang, they may sometimes be put in an awkward formation to pass brick, or to unload a car, to see how quickly they grasp the fundamentals of gang labor.

e. At the end of this time another physical examination should be made to determine how they have been affected by the work.

f. The pay for the whole course should be extremely low, but should be raised a few dollars at the end of each six months. Even with low pay and no advertising, there will be no lack of material. In fact, you will be surprised at the amount of elimination necessary, and the man who is willing to take this two and a half year course at a bare living wage is more in earnest about his future than another man would be.

g. Two is the proper number to enter one class of the course. There should not be more than four, and with two there is a strong spirit of competition. It is also friendly competition which only two can have. If three or four are in the same class, there is always one who may be the equal or better of the others, but who finds himself standing alone and does not get the coöperation of the others in the class. It is also easier to handle the work of two than of a greater number.

The students are now selected and the course proper begins.

Items 2 and 3. Training in actual work under the proper supervision.

The men should start at the lowest jobs in each department and work at each job for a sufficient time to learn the details of the work. They should do the actual work taking notes of all intricacies of the work. They should work part of the time (a small part) on night turn. They should be in the department office for one hour each morning, undisturbed, in which time they should study text books on their work and make permanent record of their notes of the day before. At unexpected times the department superintendent or assistant superintendent should give them written examinations on the parts of their work covered to date. Their study should be together, but their examinations should be written by them without aid of each other. They should see their papers and marks.

At the end of their courses in each department, they should write long theses of their course describing machines, phases of manufacture, difficulties in operation, both mechanical and chemical, and a general survey of their work. It has been found better in some plants to have the two men work together on these papers, though they should be different enough to show individual thought. No extracts from text books should be used in compiling these papers, as the idea is for the student to get the whole working for himself.

(Continued in November issue.)

WITH THE EQUIPMENT MANUFACTURERS

NEW TYPE OF BELT DRIVEN AIR COMPRESSORS

The Ingersoll-Rand Company, 11 Broadway, New York, has announced a new line of belt driven air compressors. This type is known as the "Imperial" Type "XCB" and has incorporated in it several noteworthy features of construction, including Ingersoll-Rand plate valves, for both the air intake and discharge, and the 5-step Clearance Control for regulating the compressor's output.

The plate valves used in this type of compressor have been perfected after a most complete analysis of the lightweight plate type of valve. They include the features which have been proven necessary to the successful functioning of this type of valve, the most important of these being, that the valve is supported throughout its entire operation in perfect alignment without any form of wearing guide—a very essential feature in the life of the valve.

The Clearance Control has been used with great success on the larger direct-connected electric motor driven compressors manufactured by the same Company and has proven itself to be the most satisfactory and efficient form of compressor regulation. Thousands of these direct-connected air compressors are installed in all parts of the world and are well-known by those in charge of plants where conditions call for more than 600 cubic feet of free air per minute and where direct-connected electric motor drive is used. The use of this form of regulation is a most noteworthy development in air compressor design during recent years and should be of interest to all users of air power.

The Clearance Control is a method of securing extremely efficient operation at partial loads. Under average working conditions it is a well-known fact that the demand for air is seldom steady throughout the working day and for this reason the performance of the compressor at underload is of primary importance.

With the Clearance Control the compressor is automatically loaded or unloaded in five successive steps, these steps being obtained by the reduction or addition of Clearance space to the air cylinders. The compressor will operate at full, ¾, ½, ¼ and no loads and the design of the Clearance Control is such as to secure efficient operation at any one step the reduction in input power required being practically in proportion to the reduction in output capacity.

The entire Control is automatic. If the compressor is operating at full load and the demand for air falls off this Control automatically causes the compressor to operate at one of the underload points such as ¾, ½, ¼, or no load. When the demand for air is increased the compressor automatically assumes the load in successive steps.

An extremely valuable feature of the Clearance Control is the fact that the Clearance Pockets are made integral parts of the compressor cylinder and the entire regulation is obtained by the control of the volume of air taken in and compressed.

With this method of control there is no loss of power due to wastage of air and leakage. The Clearance Pockets in the cylinder are automatically thrown in communication with the ends of each cylinder in proper succession, the process being controlled by a predetermined variation in receiver pressure. With the compressor operating at partial capacity a portion of the air is compressed into an added clearance space instead of passing through the discharge valves. On the return stroke this air expands giving up its stored energy to the pistons.

The inlet valves remain closed until the cylinder pressure equals the intake pressure. At this point the inlet valves are opened automatically and free air is taken into the cylinder for the remainder of the return stroke. Thus the inlet capacity is reduced without reducing the intake pressure. On a two-stage compressor clearance space in proper proportion is added simultaneously for both high and low cylinders giving a constant ratio of compression and maintaining conditions necessary for the highest compression efficiency throughout the entire load range.

Another added fature of this control is the maximum demand stop which will prevent the compressor being operated at any higher maximum load than is desired. This can be adjusted so that the compressor will operate on a maximum of ¼, ½, ¾, or full load and, under conditions where the load factor is comparatively low, it is of value in reducing the maximum demand, permitting a saving in the purchase of electric power—a feature found in no other type of control.

With the Clearance Control reduction in power required will be in proportion to reduction in output capacity. All the mechanism for regulating the compressor is independent. of the compressor running gear. The loading and unloading of the compressor is automatically accomplished in steps, the difference between any two steps being small enough to prevent any undue electric current fluctuation .

It will be seen that all of these features are of extreme importance the combination producing conditions requisite for the most efficient opration at full and partial loads.

This new type of belt driven compressor equipped with Clearance Control can be furnished single-stage for low pressures and two-stage for higher discharge pressure. The piston displacement capacity for 100 pounds discharge pressure ranges from 610 to 1505 cubic feet of free air per minute.

QUICK MAKE AND BREAK SAFETY STARTING SWITCHES

To withstand the most severe service in industrial plants, the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., is manufacturing a switch of very rugged construction with quick make and quick break action.

The quick make and quick break mechanism which operates the switch blade is enclosed in an external cast-iron hub or housing integral with the operating handle. This complete mechanism can be removed and replaced without disturbing the enclosed switch.

Over the fuse compartment is provided a door. The door is so interlocked that it can be opened only when the switch is in the "off" position, at which time all accessible current carrying parts are dead. This door may also be locked so that only authorized persons have access to the fuses. An outer door provided with means for sealing or padlocking opens over the whole front of the switch cabinet, making it possible to inspect the switch while in operation or to make motor-load test connections without stopping the motor. A three-hole bracket on the side of the cabinet permits the switch to be locked independently by three individuals.

NEWS OF THE PLANTS

The Norton Iron Works, Ashland, Ky., is completing plans for the erection of a new two-story plant addition, 150x200 feet, steel and reinforced concrete, to be equipped for general production. Construction will be commenced at an early date; it is estmiated to cost close to $50,000.

The Delaney Forge & Iron Corporation, 300 Perry street, Buffalo, N. Y., is planning for the early rebuilding of the portion of its plant destroyed by fire, August 29, with loss estimated at close to $250,000, including buildings and equipment. The structures destroyed include a number of shops and power plant.

The John Swane Arch Iron Works, Inc., Cypress street, Springfield, Mass., has awarded a building contract to A. M. Kramer, Springfield, for a new shop addition for increased production. The structure will be one and two-story, 32x66 feet, and equipped for general iron working. Construction will be commenced at once.

The Follansbee Brothers Company, Pittsburgh, Pa., is planning to inaugurate operations at its new plant at Toronto, Ont., now in course of construction, early in October. Erection work is being rushed to completion and double crews of workmen are being employed for machinery and equipment installation. The new plant will be run in conjunction with the other works of the company.

The Wyckoff Drawn Steel Company, Frick Building, Pittsburgh, Pa., has plans under way for the early erection of a new plant at Wyckoff, near Ambridge, Pa.; the structure will be one-story, about 60x250 feet and estimated to cost close to $75,000. William C. Undercoffler is engineer for the company.

The Lehigh Structural Steel Company, Allentown, Pa., has preliminary plans under way for the erection of additions to its plant for increased production. It is proposed to construct a number of works buildings for general production as well as other iron-working, including repair service.

The Vulcan Iron Works, Hudson and Essex streets, Jersey City, N. J., operating a marine engineering works, is planning for the rebuilding of a portion of its plant recently destroyed by fire, with loss estimated at about $250,000, including machinery and equipment. Six structures at the works were destroyed. Arthur J. Grymes is president.

The International Steel Tie Company, 16702 Waterloo road, Cleveland, Ohio, is planning for the erection of a new plant on Waterloo road, for the manufacture of steel ties for railroad service and other steel products. The structure will be one-story, 40x120 feet, and is estimated to cost about $45,000. W. C. Mahon is secretary.

After a considerable period of inactivity, a number of steel and iron plants at Buffalo, N. Y., are resuming production, with indications of early resumption of close to normal manufacture. The Lackawanna Steel Company has added a large number of employes to its working force, including a number of former workmen, and is now operating nine of its rolling mills. The company recently has arranged plans for the direct sale of pig iron, and is said to have secured orders for close to 50,000 tons for early delivery. The Wickwire Steel Company has placed a number of additional mills in service, with increased working force. The Seneca Iron & Steel Company, with plant at Blasdell, near Buffalo, is again in operation, after a shut-down of a number of months. The limestone plant of the Wickwire Limestone Company, a subsidiary of the Wickwire Steel Company, located at Lockport, N. Y., is in operation; the power house at this plant was recently destroyed by fire, with loss estimated at close to $30,000, and will be rebuilt at an early date.

The Hercules Steel Post Company, care of G. J. Pammel, secretary of the Chamber of Commerce, Niles, Mich., local representative, has plans nearing completion for the erection of a new steel plant on local site for the manufacture of steel products. It will be one-story, 50x250 feet, and is estimated to cost close to $40,000.

The American Manganese Steel Company, New Castle, Del., is planning for the rebuilding of a portion of its local plant, destroyed by fire recently, with loss estimated in excess of $200,000, including machinery and equipment.

The Illinois Steel Company is now giving employment to about 800 men at its Bay View mills, Milwaukee, Wis., and operations are being increased at the works. The working force is now about 65 per cent of normal. Four rolling mills and a number of subsidiary works buildings are in service.

The Union Steel Castings Company, Sixty-second and Butler streets, Pittsburgh, Pa., has commenced the erection of a new one-story plant addition for increased production.

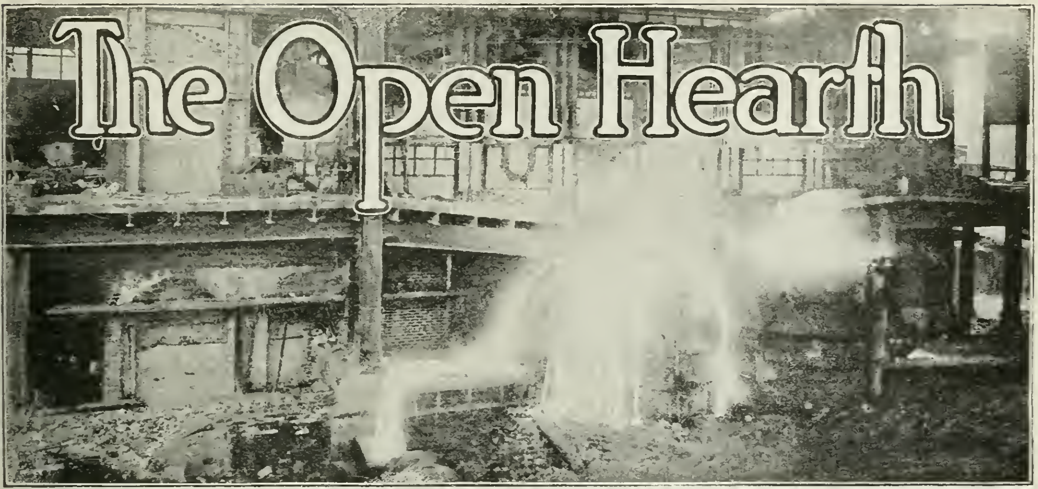
The United Engineering & Foundry Company, Pittsburgh, Pa., is maintaining active operation at its steel works and rolling mills at Youngstown, Ohio. The company has been making large shipments, aggregating close to 10,000 tons of material, to England, France and other foreign points. It is said that orders on hand insure production for some months to come.

The E. P. Bailey Steel Company, Nitro, W. Va., has commenced the construction of a new local plant, comprising a main one-story building, 75x400 feet, with a number of smaller structures, estimated to cost in excess of $135,000, including machinery and equipment.

The Trumbull Steel Company, Warren, Ohio, has preliminary plans under consideration for a new byproduct coke works at its mills in the vicinity of Youngstown, Ohio. The company has recently completed the construction of a new 600-ton blast furnace at this location and plans to blow the unit in during the fall. The furnace will be utilized for the supply of iron to the company's open-hearth furnaces across the Mahoning river.

The A. M. Byers Company, Pittsburgh, Pa., has improvement work under way at its Mattie blast furnace at Girard, Ohio. The work will comprise general over-hauling, repairing and certain remodeling, preparatory to placing the unit in service. It is said that the plant will be blown in during the fall. The company is operating 22 puddle furnaces at its No. 1 mill at this plant, and one of its bar mills.

The Open Hearth



George P. Hansen has been appointed superintendent of blast furnaces for the American Rolling Mill Co. at Columbus, Ohio. Mr. Hansen was formerly in charge of blast furnaces for the Republic Iron & Steel Company, Youngstown, Ohio.

V V

J. C. Ward of Sheffield, England, is in the United States on business. Mr. Ward is president of the Edgar Allen Steel Co., Inc., Chicago, and is also managing director of Edgar Allen & Co., which operates the Imperial Steel Works at Sheffield.

V V

Norman Allderdice recently became sales manager for the Pittsburgh and Cleveland districts of Manning, Maxwell & Moore, Inc., succeeding Robert A. Bole, who died about four months ago. Mr. Allderdice was formerly in charge of the open-hearth department of the Lorain, Ohio, plant of the National Tube Company, and under his management the open-hearth department made a splendid record. He carries with him to his new position a knowledge of steel plant machinery and equipment. He is the son of Taylor Allderdice, vice-president National Tube Company. His headquarters will be maintained at 1005 Park Building, Pittsburgh, Pa.

V V

W. C. Dennis, Birmingham, Ala., after completing a three-year contract in the general construction of a large steel works at Jamshedpur, India, has returned to that city. Templeton Tutwiler, Birmingham, is general manager of the works. The Tata Iron & Steel Co. owns the plant.

V V

Chairman Elbert H. Gary of the United States Steel Corporation left September 7 for Mexico. It is understood that the journey will not be in connection with business purposes. Judge Gary is expected to be back in New York in about four or five weeks.

V V

F. W. Gray was recently appointed assistant to D. H. McDougall, vice president of the British Empire Steel Corporation. Mr. Gray was formerly editor of the Canadian Mining Journal. Mr. Gray went from England to Canada in 1904 in the service of the Dominion Coal Company, remaining with it as confidential assistant to several general managers, and was afterwards assistant to the president of the Nova Scotia Steel & Coal Company for a year.

V V

J. A. Durfee, since March 1st, 1920, works manager of the Page Steel & Wire Plant of the American Chain Company, Monessen, Pa., has resigned his position. A notable farewell dinner was tendered Mr. Durfee, September 10, by the forty or more superintendents and foremen of the Page Works at which time he was presented with a handsome smoking set in token of the esteem in which he was held. Before actively engaging in business again, Mr. Durfee will take a vacation at his country home near Cleveland.

V V

A. Clark Moore has resigned as assistant to the president of the Globe Seamless Steel Tube Co., Chicago, with which he has been connected since November, 1919.

V V

D. D. Lewis has been appointed general manager of the Carroll Foundry & Machine Tool Company, Bucyrus, Ohio. Mr. Lewis began his career in Johnstown, Pa. He grew up in the steel industry and became identified in the building of blast furnaces and rolling mills. He served as general manager of the Southwark Foundry & Machine Co., Philadelphia; was general manager of the Buckeye Engine Company, Salem, Ohio, and prior to that time was identified with the Cambria Steel Company, Johnstown, Pa. He had been employed by the Jones & Laughlin Steel Company, Pittsburgh. Mr. Lewis was affiliated with the late Tom L. Johnson, when he built the Johnson Steel Mill at Lorain, Ohio. In addition to the Johnson Company's plant, Mr. Lewis at one time also was manager of the Algoma Steel Company, Sault Ste. Marie, Ont.

V V

Harold W. Abbott has resigned as technical supervisor at the Massena plant of the Aluminum Company of America, to accept a similar position with the Stackpole Carbon Company, St. Marys, Pa.

V V

Dr. F. G. Cottrell, head of the chemical activities of the National Research Council, will sail from France on October 11th on his return to the United States. Dr. Cottrell has spent the summer studying various phases of the chemical industry in Europe. Among other things he paid particular attention to the liquefaction of gases.

V V

W. G. Jones has been elected vice-president and treasurer of the W. A. Jones Foundry & Machine Company, Chicago, and will continue to serve as general manager.

V V

N. W. Elmer has opened an office in Quincy, Mass., as consulting engineer in conveying and mechanical handling. Mr. Elmer was formerly engineer for the Harry M. Hope Engineering Company, Boston.

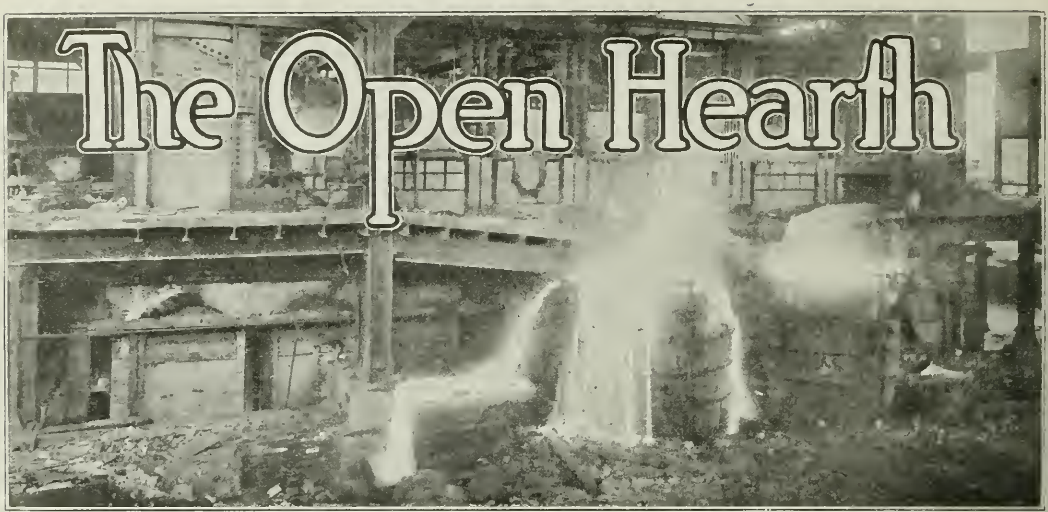
V V

Paul A. Billings, who recently was made representative of the Falcon Steel Co., Niles, Ohio, has announced establishment of headquarters at 2306 Dime Bank Building, Detroit.

V V

Dr. Raymond F. Bacon has resigned as director of Mellon Institute to take effect January 1, 1922. Dr. E. R. Weidlein has been appointed acting director.

The Open Hearth



Paul Boulanger, a director of Thyssen & Company, Mulheim, Ruhr Region, Germany, is now visiting the United States on a tour of inspection of heavy material handling appliances in use here. Mr. Boulanger recently visited the Farrell Steel Works of the Carnegie Steel Company, at Farrell, Pa., and has also investigated the ore handling machinery at Duluth. His headquarters while in this country are with F. A. Borgemeister, 50 Church Street, N. Y.

√ √

C. C. Hanch, vice-president of the National Automobile Chamber of Commerce and chairman of its taxation committee, soon is to become executive vice-president of the United States Automotive Corporation, subsidiaries of which are the Lexington Motor Company, The Ansted Engineering Company, the Ansted Spring & Axle Company, the Connersville Foundry Corporation, the Fayette Painting & Trimming Company, and the Teetor-Hartley Motor Corp. Frank B. Ansted is president of the corporation. Mr. Hanch, as the executive vice president will have charge of the operating policies of the company, and will have his headquarters at Connersville, Ind., the home office of the United States Automotive Corp. Mr. Hanch had long been connected both with the Nordyke & Marmon Co. and with the Studebaker Corp. Following his connection with these companies, he became chief of the automotive products section of the war industries board. After the close of the war he went to Europe as trade commissioner for the department of commerce, and made an investigation of trade and industrial conditions in England, France, Belgium and Italy. Mr. Hanch will retain his connection with the Homer McKee Company, an advertising company of Indianapolis.

√ √

J. M. Lloyd after serving two and a half years as superintendent of the Lowellville, Ohio, plant of the Sharon Steel Hoop Co., Sharon, Pa. has resigned, effective October 1st.

√ √

Sherwin F. Kelly is in New York, representing the French firm of C. & M. Schlumberger, Prospection Electrique. He intends to study American and Canadian ore deposits, to demonstrate their adaptability to investigate by apparatus developed by Mr. Schlumberger.

H. Voges, Jr., has resigned as vice president and general manager of the Webster & Perks Machine Tool Company, Springfield, Ohio.

√ √

Ross C. Purdy, formerly director of research Norton Company, Worcester, Mass., and for the past two years consulting ceramist at Buffalo and elsewhere, has been made permanent general secretary of the American Ceramic Society, of which he was president in 1909 and 1910.

√ √

Isaac Harter, assistant to the president, Babcock & Wilcox Company, New York, boilers, stokers, etc., has been appointed general superintendent of the company.

√ √

R. H. Mickey, who for several years represented the service department, Pittsburgh plant, Heppenstall Forge & Knife Co., has accepted a position as drop forge superintendent with the Eureka Company, North East, Pennsylvania. The Eureka Company manufacturers electrical supplies and also makes a complete line of small drop forgings.

√ √

Bradley Stoughton, Engineering Societies' Building, 29 West Thirty-ninth street, New York, having resigned after more than eight years as secretary of the American Institute of Mining and Metallurgical Engineers will resume his practice as a consulting engineer, making a specialty of financial investigations and reports to bankers, investors, directors, and examining accountants on industrial plants, engineering enterprises, iron and steel plants, etc.

√ √

William S. Knudsen, for 10 years associated with the Ford Motor Company and responsible in a large measure for its production efficiency, resigned from the Ford organization to become associated with Ireland & Matthews as general manager. Previous to joining the Ford organization he had years of experience in various capacities in the metal stamping industry. Production is running among the highest of Detroit industrial concerns.

√ √

Dr. Richard Moldenke, last week was a guest at luncheon of the Worcester, Mass., members of the New England Foundrymen's Association, that city. H. P. Blumenauer, general manager Arcade Malleable Iron Company, presided. Dr. Moldenke spoke on foundry costs and on his observation of conditions in Europe, gathered during a trip from which he recently returned.

Some Pointers on By-Product Coke Oven Operations

COKE OVEN GAS FOR THE OPEN HEARTH.

The Journal of the West of Scotland Iron and Steel Institute recently published impressions of American steel mill practice which were gained by R. Percival Smith of the Lanarkshire Steel Company, Ltd., during a recent visit to the United States. An abstract of a paper read before the June meting of this society is as follows:

As you all know, producer gas is not used exclusively in America, nor yet to a preponderating degree, in open-hearth furnaces. They have a variety of fuels. At the top of the list stands natural gas. It is considered the best fuel of all, but its uses are now restricted. In having supplies of this gas America was richly blessed. Having come into such wealth without a struggle, the American failed, however, to appreciate it fully and squandered it. It is now available for melting purposes in a few places only, and in these cases provision is made for its immediate discontinuance. The American regrets its passing. Coke oven gas is employed largely. Its constitution and heating value is exemplified by the following analysis from the coke oven plant at Clairton, the most modern of its kind in the United States:

Carbon dioxide	1.65 per cent
Carbon monoxide	3.93 per cent
Illuminants	3.32 per cent
Carbohydrates	33.53 per cent
Hydrogen	54.11 per cent
Nitrogen	3.46 per cent
Btu.	578
Sulphur, per 100 cu. ft. of gas	0.0606 lb.

Coke oven gas is very light, and consequently difficult to control. As far as my experience goes, only one firm in America uses it alone successfully; in all other cases that came under my notice tar was used with it, the tar being introduced above the gas by means of a small nozzle after passing through a special form of carbureter. Tar by itself is highly favored, in spite of certain drawbacks. Carburetion does not yet appear to have reached perfection, a black heart being very noticeable in the flame. The checkers soon become very dirty, and have to be cleaned out after a run which never seems to exceed 200 charges. The heating valve of tar as fuel for open-hearth furnaces is, however, undoubted as long as the system is in good condition, and the speed with which a furnace thus heated melts and works a charge must be considered quite satisfactory. The amount of tar used per ton varies between 30 and 40 gal. Each gallon contains about 155,000 Btu., of which, therefore, 4,650,000 to 6,200,000 are expended in the manufacture of one ingot ton. If you express the results obtained with producer gas in the same terms, you will find that tar compares very favorably indeed with it.

COKING STUDIES AT OHIO STATE UNIVERSITY

The department of metallurgy of the Ohio State University, under the auspices of and with the funds provided by the Engineering Experiment Station of the university, has installed a full scale 1-ton vertical coal retort, a complete byproduct recovery system equipped with gas meters, pyrometers and recording calorimeters. With this equipment the entire coal resources of Ohio are being surveyed with the view of obtaining accurate information concerning the possibilities of utilization of Ohio coals for gas making, byproduct recovery and coke production. Five-ton samples of each coal to be tested are obtained, duplicate 1-ton samples of this are carbonized under ordinary vertical retort conditions, the tar, ammonia and light oil recovered and analyzed, and the coke made is obtained and its quality determined by chemical analyses and physical tests. The gas made is measured in a recording and integrating Bailey gas meter and its heat value recorded in a continuous recording Smith gas calorimeter. Also a sufficient amount of each coal is crushed, sized, the coarser sizes jigged and the finer sizes tabled on a Wilfley table. The clean coal is then dried and retorted. In this way it is expected that the most complete information possible will be obtained on all of the Ohio coals. Tests will also be made on mixtures of Ohio coals with coals from other states. It is hoped to get all this information so that the cities of the state can mak the most intelligent selection of coals for the production of artificial gas to supplement the waning natural gas supply.

SOUTH AMERICAN BUSINESS SLOW.

W. C. Downs, general representative of the United States Steel Products Company, returned on the Hanson liner "Huron" from a business trip in South America. He reports that the steel business in Brazil has been for some time at an absolute standstill.

"There are large stocks of steel and steel products piled up in the ports," says Mr. Downs, "but the channels of distribution seem to be clogged. Business men expect that the movement of goods may be resumed at almost any time, but definite predictions cannot be made. However, there is no doubt that when activity is renewed a large volume of business will be created. The German sales agents are quoting very low prices on steel products, but even at that they are not doing any business because stagnation is general.

"When trade is resumed the United States should be in a favorable position to compete with European industries, as one of the great essentials—transportation—has been tremendously improved between this country and South America in the last few years. Prompt deliveries are now possible owing to the increased number of vessels in the Munson Lines and to the faster trips being made by the new ships."

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

[Required by Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly at Pittsburgh, Pa. [Report for October 1, 1921.]

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Managing Editor—F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Business Manager—F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

(Names and addresses of stockholders holding 1 per cent or more of total amount of stock:

Estate of H. A. Andresen, care Colonial Trust Co., Pittsburgh, Pa.
F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.
L. L. Carson, 108 Smithfield street, Pittsburgh, Pa.
R. H. Thiess, 108 Smithfield street, Pittsburgh, Pa.
M. M. Zeder, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

F. C. ANDRESEN, Business Manager.

Sworn to and subscribed before me this 28th day of September, 1921.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1923.)

TRADE NOTES

F. J. Ryan & Company, Industrial Furnace Builders, Wesley Building, Philadelphia, Pa., announce the establishment of three additional agencies. They are as follows:

Detroit under the direction of Mr. David P. Harr, 423 Depot St., Latrobe, Penna., who will also cover the Cleveland and Toledo districts. Chicago, under the direction of the Singer Kennedy Construction Co., 39 W. Adams St., Chicago, Ill., who will cover the Middle West. Mr. L H. Chamberlain, 72 New Montgomery Ave., San Francisco, Cal., who will cover the Pacific coast. F. J. Ryan and Company have recently moved their general offices and sales from the Franklin Trust Building, to larger quarters in the Wesley Building, 17th and the Parkway, Philadelphia. We also announce the removal of our Engineering Departments to Lancaster, Penna., where they will be established in the headquarters of the Lancaster Iron Works, with whom F. J. Ryan and Company become associated in the early part of the present year.

Harry W. Eastwood, who for the past four years has had charge of the Steel Mill and Crane Division of the Cutler-Hammer Mfg. Co., Cleveland Branch, has been made Branch Manager, taking the place of Lynn B. Timmerman, former Asst. Manager, Central District, who leaves to enter the automobile business in Lima, Ohio, after having been associated with the Cutler-Hammer Cleveland Office since 1914. Associated with Mr. Eastwood will be E. L. Windenburg, as Office Manager. Mr. Windenburg takes the vacancy made by the sudden death of Mr. A. F. Loomis on August 22. The Cleveland Office and territory of the Cutler-Hammer continues as a part of the Central District, comprising the Pittsburgh and Cincinnati Offices and territory.

Earl F. Heimpel, M. E., formerly Chief Engineer of the Edison Portland Cement Co., Stewartsville, N. J., has resigned to enter the sales force of the M. J. Dougherty Co., Piping Fabricators and Engineers of Philadelphia. Mr. Heimple who is a graduate of Lehigh University has had a wide and varied experience in the engineering field and will be located in the home office.

The A. P. Swoyer Co. merchandise stock at 17 North 7th Street, Philadelphia, has been purchased and the premises formerly occupied by Swoyer leased to U. T. Hungerford Brass & Copper Co. The Elcon Engineering Co. opened offices in Columbus, O., to engage in general contracting and engineering, specializing in elevating and conveying equipment.

A new corporation known as the G. F. Wright Steel & Wire Co. has been organized at Worcester, Mass, headed by George F. Wright, son of George M. Wright, former president of the Wright Wire Co., and it has purchased the plant of the Standard Plunger Elevator Co. at Jamesville, a suburb of Worcester. The new company will manufacture wire rope, wire cloth, wire lathing and poultry netting. Some of the special machinery has already been constructed, and it is planned to begin manufacturing at an early date.

The Gasoline Recovery Corp., New York, announces that a commercial natural gas gasoline plant operating according to the Burrell-Oberfell charcoal process is in operation at Bradford, Pa. The plant has a capacity of 900 gal. per day. It is also announced that the charcoal gasoline plant of the Monroe-Louisiana Carbon Co., located at Monroe, La., is nearing completion.

The Schaffer Engineering & Equipment Co., Pittsburgh, Pa., announces the combining of the administrative, sales and manufacturing departments in its new general offices at 2828 Smallman St., Pittsburgh, Pa.

The Cochrane Steam Specialty Co. of Massachusetts has been organized to represent in New England a number of well-known manufacturers of power-plant equipment, including the H. S. B. W.-Cochrane Corp., manufacturer of feed water heaters, steam and oil separators, V-notch meters and metering heaters, hot and cold process softeners, flow meters, precision meters, weighing meters, multiport valves and multiport drainers, also the Steam Motors Co., Inc., manufacturer of steam turbines for driving generators, pumps, fans, etc., and the D. Connelly Boiler Co., builder of water tube steam boilers. The office at 1045 Oliver Bldg., Boston, Mass., is in charge of Elliott Greene.

The Link-Belt Co., Chicago, has acquired all of the capital stock of the H. W. Caldwell & Son Co., and Frank C. Caldwell has been elected a director of the Link-Belt Co. The H. W. Caldwell & Son Co.'s plant will continue to operrate under separate corporate existence under its present name.

The Sullivan Machinery Co., Chicago, Ill., has moved its Cleveland office from 810 Park Bldg., to Room 824, Kirby Bldg. Ralph T. Stone is manager. It is also announced that a supply depot and service station for coal-mining machinery, supplies and repair parts has been opened at Seventh Avenue and Thirteenth Street, Terre Haute, Ind. H. T. Wiley is in charge.

Charles Cory & Son, Inc., 183-187 Varick St., New York City, has obtained the manufacturing and selling rights for the Royer line of portable and stationary flow indicators. These indicators are designed for indicating the flow of all kinds of corrosive and non-corrosive gases, vapors and liquids and were formerly manufactured and sold by the A. H. Sloan Co. of Detroit, Mich. It is intended, through the increased manufacturing facilities provided by the Cory Company, to increase the production of these meters and make further extensions to the Royer line.

TRADE PUBLICATIONS

"Wheeler Condensers" is the title of the new general catalogue issued by the Wheeler Condenser & Engineering Company, Carteret, N. J., which illustrates and describes a complete line of condensers and accessories for stationary and marine service—including Wheeler condensers, vacuum pumps, centrifugal pumps, cooling towers, condenser tubes, feed water heaters, etc., Many of the designs described are of special interest to power plant engineers, since they represent most recent engineering improvement. Among them are: a new design of a 26-inch vacuum surface condensing equipment adapted for engine work and dispensing with combined auxiliary pumps; the Wheeler steam jet air pump with combined inter-condenser and heater operating at maximum efficiency without complicated and expensive accessories; the Wheeler jet condenser with expansion joint between condenser body and a turbine and a centrifugal removal pump having a special vertically split casing. In a section devoted to Crescent Brand condenser tubes, the precision that enters into each step of the manufacture of the highest quality tubes is explained. A condenser data sheet is included with each copy.

The Ashland Fire Brick Co., Ashland. Ky., has published an 8-page illustrated bulletin entitled, "Fire Brick for Rotary Cement Kilns." The booklet contains a short resume of conditions to which various types of fire brick are adapted.

W. S. Rockwell Company have issued Bulletin No. 232—"The Variety of Furnace Design", which is the third of the series dealing with fundamentals that influence the quality and cost of heated products. It illustrates the relation of type and arrangement of heating equipment to cost of production, and the many factors that must be considered in adapting such equipment to individual manufacturing conditions.

The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., NOVEMBER, 1921 NO. 11

Modern Sintering Plant of the Cambria Steel Company

A Description of Complete Installation of Large Capacity and of Rugged Design, Completely Equipped with Labor Saving Machinery, Ample Unloading Facilities and Large Storage Bins.

By H. V. SCHIEFER

WORKING from preliminary designs of the Cambria Steel Company, Arthur G. McKee & Company, Cleveland, has designed and erected a complete sintering plant at Johnstown, Pa., for the sintering of a large stock of flue dust on hand and to sinter the flue dust as produced.

With the present freight rates on ore from lake ports, this plant will effect appreciable economies in the production of pig iron.

The plant embodies two of the large size Dwight & Lloyd sintering machines. The entire plant is equipped with the most improved type of machines for reducing labor to a minimum incident to the handling of over 1,000 tons of material daily.

The entire plant covers an area of about 80 ft. by 300 ft. Advantage is taken of a hillside location to eliminate the installation of an expensive trestle. Not only is a trestle eliminated, but an area of otherwise useless space is occupied to advantage.

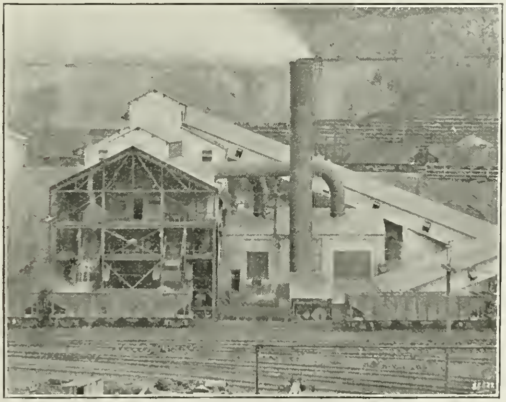


Fig. 1—Discharge end of sintering plant.

The plant is designed for the production of 800 tons of sinter per day. It is arranged so that stock pile flue dust, direct flue dust or a mixture of the two in any proportions may be used. Mill scale and ore may also be used if desired. Duplication of machinery is installed insofar as possible so that a shut down of one piece of equipment will not shut the plant down.

Raw material is brought to the plant in standard gauge railroad cars on two tracks that are about 40 ft. higher than the finished sinter tracks. Two unloading track hoppers are provided. Each hopper has a horizontal area of 30 ft. by 30 ft. and accommodates two cars, making a preliminary storage of eight carloads in and on the hoppers. The unloading tracks extend on a ledge around the hill so that at least 25 cars may be spotted beyond the track hoppers and allowed to coast into position on the hoppers.

The entire top area of the hoppers is covered with a heavy cast iron safety grillage. The openings in the grillage are about 4 in. by 5 in., which eliminate the possibility of a workman falling into the hopper. At the same time it prevents large lumps and all large foreign objects from dropping into the hopper and plugging the feeders below. The grillage is made heavy enough to allow for the breaking up of frozen flue dust with sledges in the winter. The track hoppers are covered over with a steel house sheeted top and sides. Windows are provided located high enough up to prevent breakage and to allow for good lighting.

The track hoppers are of steel plate. At the bottom of each is provided an opening equipped with a rack and pinion gate for regulating the flow of material from same.

Under each gate a slow moving conveyor is placed. Each of these conveyors consists of two strands of extra heavy roller chain between which overlapping steel pans are attached. Flue dust is received at times containing as high as 12 per cent, making the design of a self feeding conveyor of importance. These conveyors act as feeders as well as conveyors. They are placed at an angle of about 25 degrees from the horizontal, are about 60 ft. long and discharge into two revolving screens.

Years of experimenting have been done in trying to successfully screen all kinds of flue dust. The screens as installed are taking the material as it comes and have proven their worth. The screens are of the revolving center shaft type and are a truncated pyramid in shape with six sides. The screen cloth, which is made up of 3/8-in. wire, is mounted on frames that are easily removable. Structural steel trolley beams are located directly over the screens to expedite repairs. The screens are 4 ft. in diameter at one end, 6 ft. at the other end and 12 ft. long and mounted on 6-in. shafts.

The over-size coke that is screened out of the flue dust drops into other bins and thence along through chutes to railroad cars. This over-size coke can be sent to the furnaces and used as fuel.

Each screen is driven by a direct connected 25-hp motor. The conveyors are driven through gearing and a clutch from the screen shaft. All of the gearing as well as the entire screen is enclosed in heavy steel guards for protection to workmen and to prevent dusting.

The unloading and screening equipment will handle 1,000 tons in 10 hours, thereby cutting the unloading labor to a day turn of 10 hours only. To permit this, four storage bins are provided with a total capacity of 640 tons, which will supply the sintering machines for the 14 hours that the unloading gang is not working. There are six storage bins in all; two under each of the two screens for flue dust and two provided for returns to be described later. These bins are all placed in a straight line. Each bin is provided with a standard McKee revolving disc feeder. To eliminate the difficulties encountered in previous feeders for this work, a feeder of new design has been provided that is extremely rugged and designed to take up the wear incident to the material handled. Each bin bottom is fitted with a cast iron cylinder, open top and bottom, 48 in. in diameter and 30 in. high with an opening in the side provided with an adjustable slide gate. Directly under the cylinder is placed a horizontal revolving disc made of ¾-in. boiler plate. This disc is bolted to a spur gear and is driven through a vertical shaft provided with a bronze thrust bearing. As the thrust bearing wears the spur gear simply slides further along the teeth of the driving pinion. This was not the case in previous designs where a bevel gear and pinion were utilized. As the disc revolves the material is brought against a scraper which directs it through a 7x9-in. opening in the side of the feeder. This opening is fitted with an adjustable sliding door so that the discharge of the material may be regulated. The feeders are all driven from one line shaft and any one or all may be cut out by means of clutches.

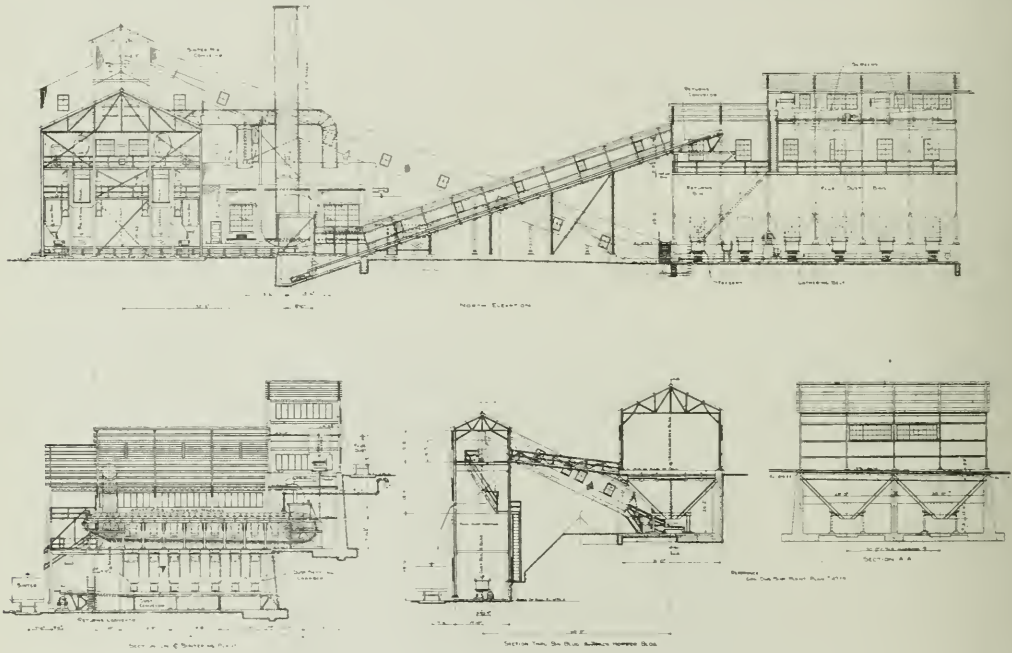


Fig. 2—Section through the new plant.

The discharge openings from all feeders are arranged to discharge onto a 30-in. belt conveyor. This belt conveyor and all feeders are driven by a variable speed motor. The variable speed is necessary since the speed of the sintering machines is occasionally changed, requiring more or less material.

By the manipulation of the gates in the feeders any desired proportions of materials may be obtained and at the same time a preliminary mixing is obtained. The 30-in. belt discharges the proportioned material on an inclined belt conveyor that carries the material to the top of the plant and discharges into a super hopper.

The super hopper acts as a reservoir only and would be unnecessary if it were practically possible to run the entire plant in positive synchronism. The bottom of this hopper is bifurcated and is fitted with two McKee revolving disc feeders that are duplicates of the ones under the storage bins except that they run at a higher speed.

From the point where the material leaves the super hopper the plant is divided into two complete units, each consisting of a pug mill, a sintering machine, fan, and the necessary auxiliaries.

The feeders under the super hopper are driven from a counter shaft of the sintering machines and work with them in positive synchronism so that a speeding up of the sintering machines automatically speeds up the feeders. A change of hearth bed depth is accomplished by an operating lever located on the operating floor which raises or lowers the opening in the feeders.

From the feeder the material drops into a McKee pug mill which thoroughly mixes the various ingredients. Water is added in the pug mill to give the proper consistency necessary for sintering. The pug mill is a cast iron trough about 12 ft. long in which two square shafts revolve in opposite directions. Manganese steel paddles are mounted on the shafts. Ball-bearings running in oil are used to take the thrust. The shafts are equipped with couplings so that they may be quickly removed without disturbing the driving gear. The bottom may be dropped and cleaned while the mill is in operation.

The pug mills are extremely heavy with an entire cast iron frame and were designed and built by Arthur G. McKee & Company. Each pug mill is belt connected to a 20-hp motor. The pulley shaft is at right angles to the paddle shafts of the mill and the transmission is effected by means of bevel gears.

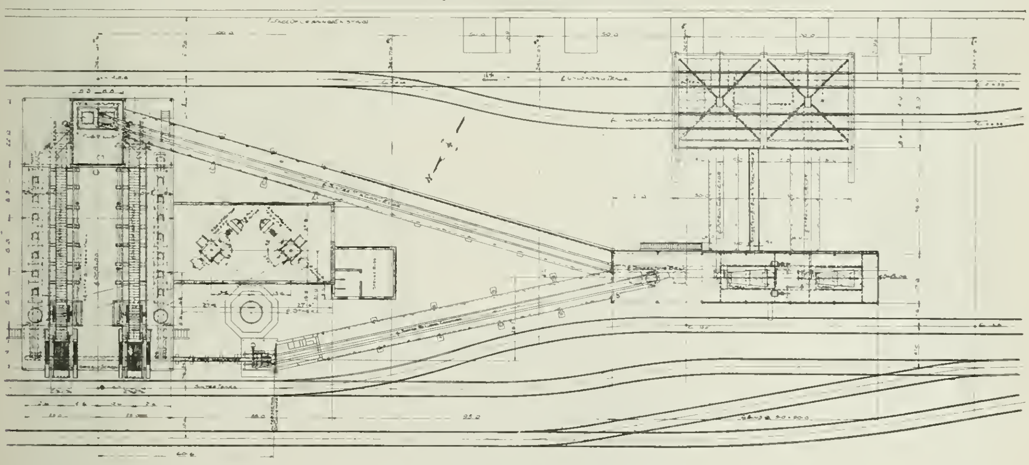


Fig. 3—General plan of the plant.

The success of the sintering process depends to a considerable extent on the quality of the mixture as it comes to the hearth of the sintering machine. This factor was given careful attention in designing the plant and as a result the pug mill and sintering machine in each unit are arranged in direct sequence. This insures immediate supervision of the material which is being fed to the hearth of the machine and enables prompt regulation of the content of the mixture in the pug mill.

To maintain a uniform layer of material on the hearth, a swinging spout was constructed to feed the sinter mixture from the pug mill. The spout is pivoted at the discharge chute of the pug mill and by means of a rope and counterweight attached to a crank on a countershaft of the sintering machine, it is swung back and forth at right angles to the direction of the travel of the machine. In this way even distribution of the sinter mixture on the moving hearth is assured.

The sintering machines without any auxiliaries were furnished by the American Ore Reclamation Company, Chicago. They consist of endless trains of pallets or grates which travel under ignition burners and over wind boxes equipped with downdraft suction fans. These machines have an effective grate area 42 in. wide and 57 ft. 4 in. long. The old standard Dwight & Lloyd machine was 42 in. wide and 25 ft. 6 in. long, and the lower strand of pallets rolled by gravity along an inclined track back to the driving sprocket wheels. The much greater length of these new machines makes the use of a gravity return undesirable and the lower strand of pallets is, therefore, positively driven along the lower track by sprocket wheels at the discharge end. These discharge end sprocket wheels are driven in synchronism with the driving and sprocket wheels. This synchronous drive insures that the empty pallets are returned to the driving sprocket wheels at the same rate of speed as that of the pallets on the upper strand.

On these new machines, sliding friction between the pallets and the wind box tops is eliminated by carrying the weight of the loaded pallets on wheels running on rails. The pallet wheels are fitted with renewable steel bushings and have large oil receptacles. The sprocket wheel teeth drive against tooth surfaces cast in the frame of the pallet and against the pallet wheels. This allows the pallet wheels to properly perform their rolling function around the curved tracks at the drive end.

All of the gears and the sprocket wheel teeth on the machine are made of steel castings. All gears and the shaft couplings are wholly enclosed in heavy sheet steel guards. The sprocket wheel teeth are removable and are machined in jigs so that they are interchangeable and when worn may be replaced without tearing down the larger members of the drive.

An important feature of the new machine is the use of seal bars on the pallets, which automatically maintain air-tight joints between the pallets and the tops of the wind boxes. These seal bars are made very light and by their own weight bear on the finished surfaces of the wind box tops, and also fit against the finished sides of the pallet slots in which the bars are hung.

As the pallets travel under the swinging spot, they receive a layer of sinter mixture. The depth of this layer is a variable one, depending on the fineness or coarseness of the mixture. There is always some critical thickness for any specific mixture at which the greatest quantity and the best quality of sinter is produced. With any arrangement of bins and feeders the thickness of the sinter mixture layer varies considerably from day to day.

According to the principles involved in making sinter under the Dwight & Lloyd patent, there is sufficient carbon in the sinter mixture to support combustion, provided the necessary ignition and oxygen are supplied. Flue dust from its very nature is a homogeneous mixture of fine ore and coke and at this plant the flue dust contains enough coke so that it is not necessary to add any further carbon to the mixture.

The ignition burner, which was built by Arthur G. McKee & Company, is 2x4 ft. overall and is suspended directly over the pallets. Gas for ignition is taken from the top of a 24-in. main that runs through the plant and supplies the Cambria Works from the Cambria Steel Company's new Rosedale plant. By taking off the top of the main a very clean gas is obtained so that practically no trouble is experienced from an accumulation of tar. The necessary air is supplied by Roots positive pressure blowers. These blowers are motor driven and are located on the ground floor. The flame must be of sufficient intensity to positively ignite the entire surface of the charge without completely drying it. If the mixture is prematurely dried, the sintering action is retarded. The pallets travel at a speed of from 30 to 90 inches a minute while combustion is going on. Finally when the combustion is completed, the pallets arrive at the end of the machine where they are dumped by dropping one pallet at a time down a curved track. Each pallet hits the one ahead of it a blow that throws the material against an inclined grizzly screen.

A suction of about 20 inches of water is maintained by means of a fan for each machine which is directly connected to a 350-hp motor. The fans have 100-in. impellers; they revolve at from 600 to 720 rpm and have a capacity of 30,000 to 60,000 cu. ft. of gases per minute each. The fan is enclosed in a steel casing and the bearings are water cooled. The fans were manufactured by the Buffalo Forge Company, Buffalo, N. Y. The fans are located in a separate brick building 27x54 ft. Underground flues lead the gases to a single stack 90 in. in diameter by 80 ft. high.

As the sinter leaves the machine it is dumped on a grizzly screen 5 ft. wide by 12 ft. long, set at an angle of 32 degrees with the horizontal. The bars of the screen are spaced to give a clear opening on ¾ inch. The finished sinter passes over the screen and falls into railroad cars.

The openings in the grizzly screen are designed to give between 20 and 30 percent screenings. These screenings are called "returns." It is desirable to have this large amount of returns since when mixed with the raw flue dust we not only get better sintering action, but also decrease grate bar breakage.

It has been the custom in the past to handle the returns in railroad cars, placing a depressed track under the sinter screen. With the large percentage of returns this not only requires a number of cars in this service constantly, but requires expensive shifting and unloading. This has been eliminated in this plant and the returns are returned into the system by means of conveyors.

As the returns drop through the grizzly screen they are caught by a hopper that will hold about 25 tons. This hopper is provided with a gate that feeds onto a cast iron pan conveyor. The returns at times are red hot and must be cooled with water. This puts a severe condition onto the conveyor. The conveyor itself consists of two strands of extra heavy bushed roller chain between which are hung cast iron overlapping pans. All articulation points of the chain are either chilled iron or case hardened steel. The conveyor is driven by a 7½-hp motor through spur gear reductions. The gearing is protected with heavy plate guards. This conveyor extends beyond the building about 30 feet without a covering, giving the hot material a chance to cool before being discharged onto an inclined belt conveyor which elevates the material into either of two storage bins. These two bins having a capacity of 160 tons each, are at the same level and in line with the four stock bins above mentioned. They are provided with feeders and discharge onto the same belt that receives materials from the other stock bins.

Under each sintering machine there is a dust settling chamber through which the hot gases pass before entering the fans. These are steel bills each approximately 5x10x60 ft. and provided with seven cleaning doors each. These bins must be cleaned every 24 hours. It has been the custom in previous sintering plants to open the doors and drop the accumulated material on the floor and then have the material cleaned away with wheel barrows. The hand handling has been eliminated in this plant by the use of a belt conveyor placed under each dust chamber. These belt conveyors discharge into the cast iron pan conveyor above mentioned. The material is mixed with the returns in the return bins.

Views shown on Page 636 are descriptive of the following:

No. 1—Complete plant view showing discharge and sintering plant and bin building at the right.

No. 2—Operating floor showing super-hopper, pug mills, feeders, ignition burners and Dwight & Lloyd sintering machines.

No. 3—Sintering machine return track and machine drive.

No. 4—Ground floor showing wind boxes and dust collecting belt.

No. 5—Raw material feeders in bin building.

No. 6—Raw material unloading station showing cars discharging flue dust into track hoppers.

No. 7—Suction fan showing switchboard in background.

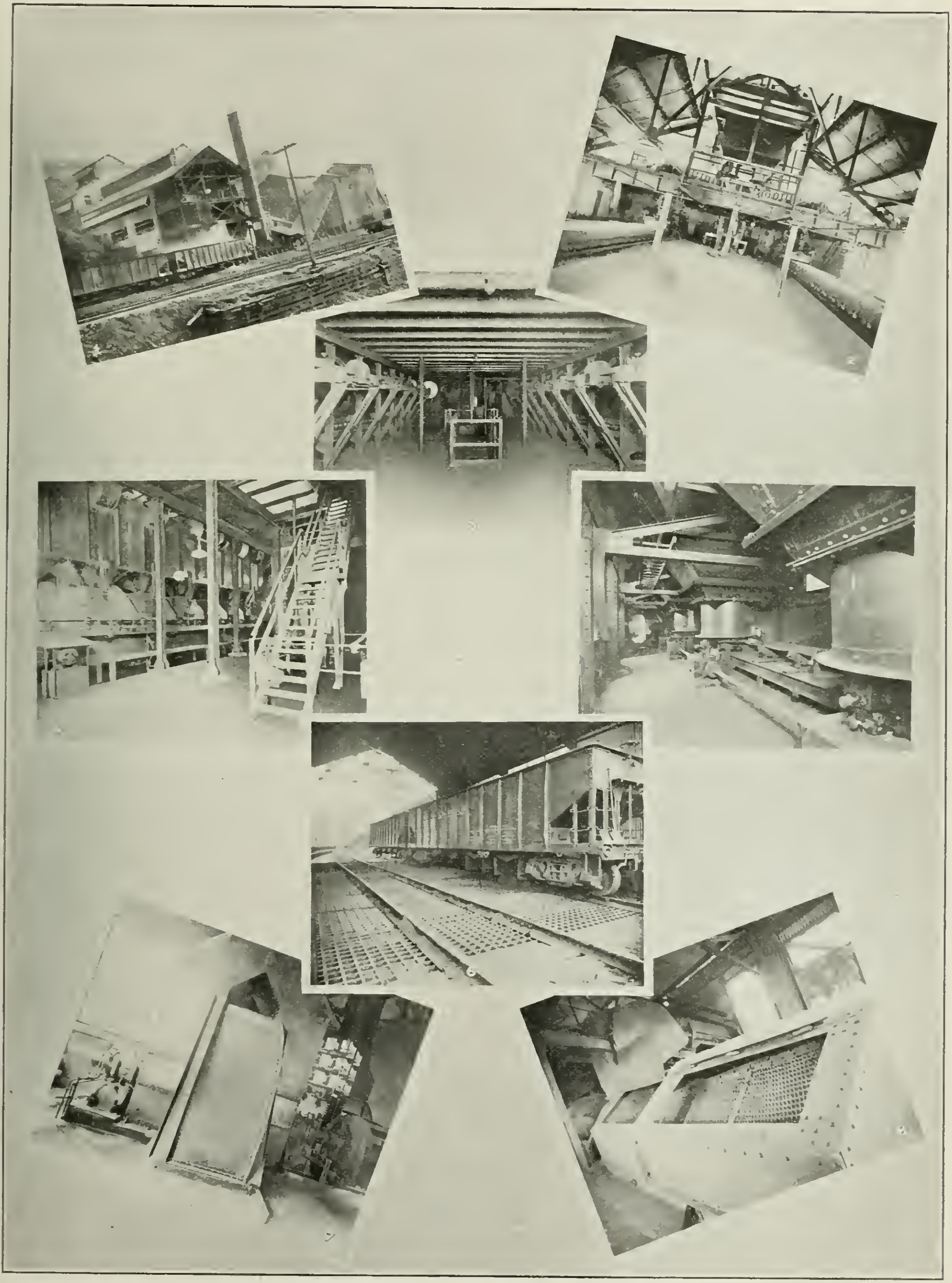
No. 8—View of truncated raw material revolving screen.

The motor equipment was supplied by the Westinghouse Electric & Manufacturing Company.

Adhering to the geneal policy of the Cambria Steel Company, the entire plant was designed to make it an absolutely safe plant for the workmen. All gearing, shafting, belting and all moving parts are enclosed and all platforms, etc., are provided with hand railing and toe boards. All floors and platforms are of concrete to allow for flushing out the entire plant with a hose.

The buildings are all substantial, being either heavy steel framing or brick. A brick office building and service station make the plant complete in itself.

All machinery is of heavy design to reduce wear and renewals to a minimum. By the correct choice of labor saving machinery and the utilization of centralized elec-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trical controls and interlocks, the working crew is reduced to 12 men.

The entire plant, with the exception of the electric wiring, was designed and built by Arthur G. McKee & Company, Cleveland, the erection work being under the direction of Mr. H. B. Pearson, Jr., general superintendent.

The interests of the Cambria Steel Company were looked after by Mr. W. C. Frank, assistant chief engineer, and Mr. H. C. Proudfoot, electrical engineer, under the direction of Mr. H. A. Berg, assistant general superintendent.

Comparison of Beehive and By-Product Coke

Many Advantages of By-Product Coke Over Beehive Coke Are Given—By-Product Coke Has Greater Strength, Is More Uniform in Size and Contains Less Small Coke and Breeze.

BEFORE entering into a comparison of beehive and by-product coke, the general characteristics which govern the fuel value of coke in general will be briefly discussed. As practically all beehive coke is used for metallurgical fuel, the domestic coke field will be omitted entirely. The principal metallurgical uses are in the foundry cupola and the iron blast furnace, so their requirements will be used as a basis for discussion. Other metallurgical processes, such as lead and copper smelting, etc., are in many respects very similar in their requirements to the iron blast furnace.

The governing qualities of a good metallurgical coke are proper physical structure, size and analysis.

For best results as metallurgical fuel, it is essential that the coke be of free burning structure. This applies both to foundry and blast furnace coke. Free burning qualities are controlled by the cell structure, which includes porosity, or percentage of cell space in the coke, and the physical condition of the carbon composing the cell walls. In general an open, porous coke, whether the cells are small or large, is free burning. A dense, finely porous coke is generally slower burning. When in either case the cell walls are heavy and solid or the carbon is in a more or less dense and refractory form, or both conditions are present, the coke is rendered less combustible or slower burning. The cell space, or porosity, governs the surface exposed to the attack of oxygen, while the cell wall structure and condition of the carbon controls the rapidity of oxidation or combustion of the carbon when attacked. So-called hardness is believed to be dependent on these same physical characteristics and the hardness test is a method for empirically gauging the combustibility.

The proper size of coke depends largely upon the nature of its treatment before using and the conditions under which it is burned. In foundry practice the coke receives very rough treatment at the consumer's plant, being forked and thrown at least three times and often more before coming to rest in the cupola. Then the heavy scrap and pig iron is thrown in onto the coke with a drop anywhere up to 15 feet, or even more in large cupolas. As any coke is essentially brittle and friable to some extent, it is necessary that it should start out at rather fair dimensions in the car, as received, in order to reach its destination in the cupola with a reasonable final size. Blast furnace plants handle the coke much more carefully before charging and it receives less severe treatment during charging and in the furnace. Hence the size as received is fairly well maintained and a smaller initial average size is permissible.

In the foundry cupola and blast furnace the coke acts not only as a fuel, but also as a medium for maintaining proper openness and the distribution of material in the whole stock column. The charge in a cupola is very open, due to the nature of the materials dumped in. Therefore, the coke maintains the distribution of the pieces of pig iron and scrap and insures their proper heating from all sides. As the column is open only a low wind pressure of a few ounces is allowed for. Thus any tendency toward small coke and a dense, tightly packed stock column, either throughout or locally, is immediately followed by improper penetration of air blast and channeling. In the blast furnace the ore materials are generally fine and earthy. As the whole column is fairly dense a strong air blast pressure of 15 to 20 lbs. is maintained. The coke here acts to open up the stock column and allow proper distribution of the rising gases. If of uniform size the coke can be quite small; but any tendency toward an appreciable percentage of pea and breeze sizes has very bad effects on furnace practice. If on the other hand the size is too large, the rising gases pass out too freely with channeling, which results in insufficient exchange of heat and chemical reaction with the ore. Large foundry coke is not good blast furnace fuel, especially for smaller blast furnaces, for this reason. Roughly it may be said that an average size of about two fists together is right for good foundry coke, while an average size of one fist is right for blast furnace coke. Both must be free from fines.

The combustibility and size of the coke depends both upon the coal or coals used and the method of carbonization. Analysis, however, depends entirely upon the coal charged. All other things being equal, there is no doubt but that the lower sulphur and lower ash coke is preferable. However, coke structure and cost must also be considered. A high sulphur, high ash coke with good free burning characteristics and of proper size is much superior in the blast furnace to a low sulphur, low ash coke which does not burn freely or that is too small or too large. This is true to a somewhat less extent in the foundry cupola, if proper attention is given to slagging off the impurities. The melting action in the cupola, and the comparatively small volume of slag normally allowed for, entails a strong tendency for the sulphur in the coke to enter the iron. Hence, in general, foundry coke should not run over 1.00 per cent sulphur and 12.0 per cent ash. In the blast furnace, however, the high temperature and large volume of slag allows of the fluxing off of large amounts of sulphur if a hot hearth and proper slag conditions are maintained. These conditions are dependent upon a very free burning coke of proper size. Such a coke may carry up to and even over 1.5 per cent sulphur and 15 0 per cent ash and show excellent furnace practice with high quality, low sulphur pig iron production. On the other hand a slow burning coke running less than 1 per cent sulphur and 12 per cent ash will show poor furnace practice, with hot top temperature and cold hearth, producing off grade high sulphur iron. Analysis and cost, therefore, do not determine proper foundry and blast furnace mine true coke value.

In comparing by-product and beehive coke it is necessary to allow for the different conditions of carbonization. The beehive oven is charged with a layer of coal about 24 to 27 inches deep, depending on whether the charge is for furnace or foundry coke. The bed of coal is not compressed at all and is absolutely free to expand vertically during coking. The coking temperature is low —about 800 to 900 deg. C.—and the coking time 48 hours for furnace coke and 7 hours for foundry coke. Heat for coking is generated by the partial combustion of the evolved gases and some of the coke itself, due to the admission of air through a suitable hole in the bricked-up door. Coking is practically entirely from above and finally penetrates the whole depth of the charge. The final coked bed will run from 26 to 30 inches in depth. Beehive coke is, therefore, columnar or fingery in form and of a length up to the depth of the coke bed. Due to the long, slow travel of the final distillation gases from the bottom of the charge through the hot coke, partial decomposition, or cracking, takes place, resulting in a deposited layer or "skin" of silvery carbon. This gives the coke a decidedly pleasing, bright, metallic and clean appearance. As the whole bed is perfectly free to expand during the plastic stage of coking, the coke is generally quite light and porous. The low coking temperature and other conditions results in the carbon in the cell walls being in a very combustible form. Beehive coke is, therefore, usually free burning. Owing to their fingery or columnar form, the coke pieces tend to mesh together in parallel upon agitation or shaking down. The presence of the smooth carbon skin aids in this packing tendency. As a result of an apparently large sized beehive coke will give a comparatively compact stock column in the furnace or cupola.

By-product coke is made in narrow chambers or ovens about 10 ft. high, 37 ft. long and 15 to 20 in. in width. The coal is charged into the top and fills the oven, allowing only sufficient space above for the evolved gases to pass off. All heating is accomplished by burning gas in flues in the oven walls. No air at all is admitted to the oven chamber during carbonization of the charge. The coking temperature is normally about 1000 deg. C. and coking time at least 1 in. per hour total, or 15 to 20 hours, depending upon oven width. This is often exceeded materially by carrying higher temperatures. As the coal is coked in horizontally from both sides, there is always a line of cleavage at the center of the oven. Thus the coke from an oven of 17-inch average width can be only 8.5 inches long or one-third the length of beehive coke. The coke is, therefore, more blocky and chunky in form. The charge being confined between walls during carbonization, there is less freedom for expansion during the plastic stage and hence a stronger, more compact coke, which still maintains the necessary porosity and free burning characteristics, is produced. Where the width of ovens is properly proportion to the coal being coked, the temperatures are such that the cell walls are thin and composed of carbon in the most free furning form. As the gases are evolved rapidly and pass through only a thin layer of coke, even at the end of the coking period there is not the cracking and deposition of carbon as found in the beehive oven. Therefore, by-product coke is porous clear to the surface and is generally dull and lusterless. Under certain conditions a very small deposit of carbon, in sooty form, is produced, which gives the coke a very dark, irregularly shaded surface. This general appearance has no connection at all with the combustibility and analysis of the coke itself. The absence of carbon skin makes the coke surface rather rough and slightly jagged. This, in conjunction with the chunky, block form of the by-product coke, prevents its packing down as closely as beehive coke. For this reason the comparatively small sized by-product coke will give just as open a blast furnace stock column as the larger sized beehive coke. The ranges of sizes not being nearly as great, the more uniform sized by-product coke gives a better and more regular stock and gas distribution in the furnace.

It is, of course, well known that the beehive ovens can make coke from only the best coking coals and that no mixing of coals can be economically provided for. Each beehive plant is located at, and receives its coal from, a certain mine or group of mines. As the production of coal from one mine, or group of mines, is not sufficient to supply coke for a large blast furnace plant, it becomes necessary to use coke from several different beehive oven plants, with consequent variation in quality. No matter how carefully shipments are apportioned, the fuel from day to day will vary as coke is received from the different shipping plants. Although the average quality of the cokes may be excellent, the variation in their individual characteristics will show up in a tendency toward irregular furnace practice.

By-product ovens are usually located at or near the blast furnace plant and can coke a wide range of coals, entirely out of the question for beehive ovens. By maintaining a constant coal mixture, uniform coke is produced and blast furnace practice can be adjusted to regularly use this coke to best advantage. The cost of the by-product coke and its quality are, therefore, much more under control than is the case with a beehive coke supply.

In conclusion it may be said that by-product coke has combustibility equal to or greater than that of beehive coke. It has greater strength, is more uniform in size and contains less small coke and breeze. The analysis is strictly controllable, as coals of satisfactory chemical quality can be mixed. In addition there is the advantage of a uniform coke of any desired structure, size and analysis produced from the by-product coke plant as compared to beehive coke from several different plants.

INDIA TO INCREASE STEEL PRODUCTION.

India, during the next five years, will witness considerable development and growth in its metallurgical industries, particularly those of iron and steel, in the opinion of Mr. S. M. Marshall, consulting engineer for the Tata Iron & Steel Co.

At the present time there are only three industries of this kind in operation. There are three large new plants under construction or in serious contemplation. These are the Indian Iron & Steel Co. near Asansol, the Eastern Iron Co., whose plant will probably be located near Chandil on the Bengal-Nagpur line from Sini to Adra, and a third company whose plant will probably be at Manharpur.

Modern Method of Steel Billet Grinding

Advantages of Grinding Over Chipping in Relation to Wheel Cost, Labor Cost and Overhead—Grinding Wheels Remove Seams Cleaner Than Chipping Chisels

By R. H. CANNON*

WHEN molten steel is poured into an ingot mold, there are almost always a few flaws in the ingot after it has cooled. Some grades of steel are more troublesome than others in this respect, but in spite of the greatest care in pouring and cooling it seems to be next to impossible to produce a perfect ingot. There will be checking, blow holes, slivers caused by splashes on the side of the mold, slag inclusions, piping, etc. Some of the blow holes become oxidized as do cooling checks and slivers and these defects cause seams in the steel which cannot be welded together by reheating and working. Unless removed by mechanical means they will persist down to the finished product.

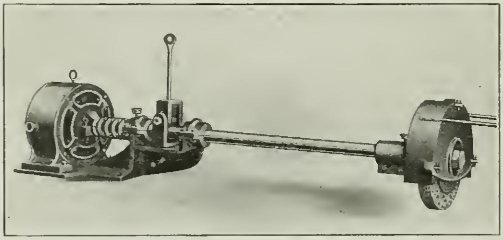

Fig. 1—A substantial type of motor driven swing frame grinding machine.

Seams are usually removed when the steel is in the form of a billet and there are two methods of accomplishing it: by the pneumatic chisel or by the grinding wheel. The softer steels can be handled to good advantage by a chisel, but for the harder ones it is necessary to use a grinding wheel. It will cut high carbon and high speed steel more efficiently than any other tool.

A grinding room or "cleaning room" as it is sometimes called should be equipped with a number of swing frame machines. This type of machine is the only practical one for handling billets. While all swing frame machines may appear to be of the same general type to the casual observer, to those who have seen a large number of billet grinding rooms there are certain very important differences. Let us point out certain features which should be insisted upon when this part of the equipment is being selected.

The pulleys and belts should be large enough so that there will be a minimum of slippage. Especially on the vertical belt with a rather small pulley at the bottom there is likely to be a great loss of power when too heavy pressure is being exerted between the wheel and the work. To do away with this difficulty pulleys and belts should be generous in width, depending of course on the diameter and width of the grinding wheel. The pulleys should be large enough in diameter. The most common type of swing frame machine is run from a countershaft and is suspended from the ceiling as shown in figure 1. The weight of the wheel head is taken care of by a counterweight. Another type is suspended by a vertical bar from a trolley overhead while the power is furnished by an individual motor on the end of the horizontal shaft. Thus the motor balances the wheel head. The wheel runs sometimes perpendicular and sometimes by the use of beveled gears parallel to the horizontal shaft. In either case positive power is insured. It will be found, however, that excessive vibration occurs when wheel head and motor are so delicately balanced in this way, whereas the counterweight held by a cord passing through two pulleys on the ceiling absorbs a great deal of the vibration. Therefore the more common or counterweighted type is preferable.

Most swing frame machines have the wheel mounted between the spindle bearings, while one or two manufacturers have the wheel on the end of the spindle. The latter method presents some difficulty in the question of balance but this can be overcome and a great many concerns are now using machines of this type. Quite a few of them are of their own design. The advantages of having the wheel "overhung" or mounted on the end of the spindle are obvious at once. If the machine has to be taken apart and the bearings removed to take out the old stub and mount a new wheel an average of at least 20 minutes is consumed. On the other hand a new wheel can be mounted on the end of the spindle in approximately three minutes. When it is necessary to take the boxes apart, it is a difficult task to adjust them without having them too tight or too loose. The painstaking job of adjusting shims is necessary, and after it is all done a certain amount of dirt and abrasive is bound to have gotten into the boxes, causing excessive and unnecessary wear.

Billets usually come to the grinding room directly after cogging or rolling. An ideal arrangement is to bring the billets in on a lift truck leaving a loaded body on one side of the inspection table and an empty body on the other. A group of about six grinders will handle that particular load. As each grinder finishes his billet he places it on the inspection table, and the inspector either passes it on to the empty truck body or returns it beside the grinder's bench to be touched up. This system involves a minimum of handling and insures careful inspecting. In some mills the inspecting is done before grinding and a chalk mark placed around each seam. The grinder then confines his attention only to the spaces within these circles. A better practice is to instruct the grinder to remove every seam. He "skins" the billet all over, that is, he removes every bit of scale and can then see each seam plainly. Some concerns "pickle" the billets in acid to remove the scale, but the practice of removing it by the wheel takes only a moment and shows up the seams better than by any other method. Grinding should be done across the seams, not only because this method is most convenient but because the seams are then plainly visible. If ground longitudinally the grain marks will tend to obscure the seams.

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*Sales Engineering Department of the Norton Company.

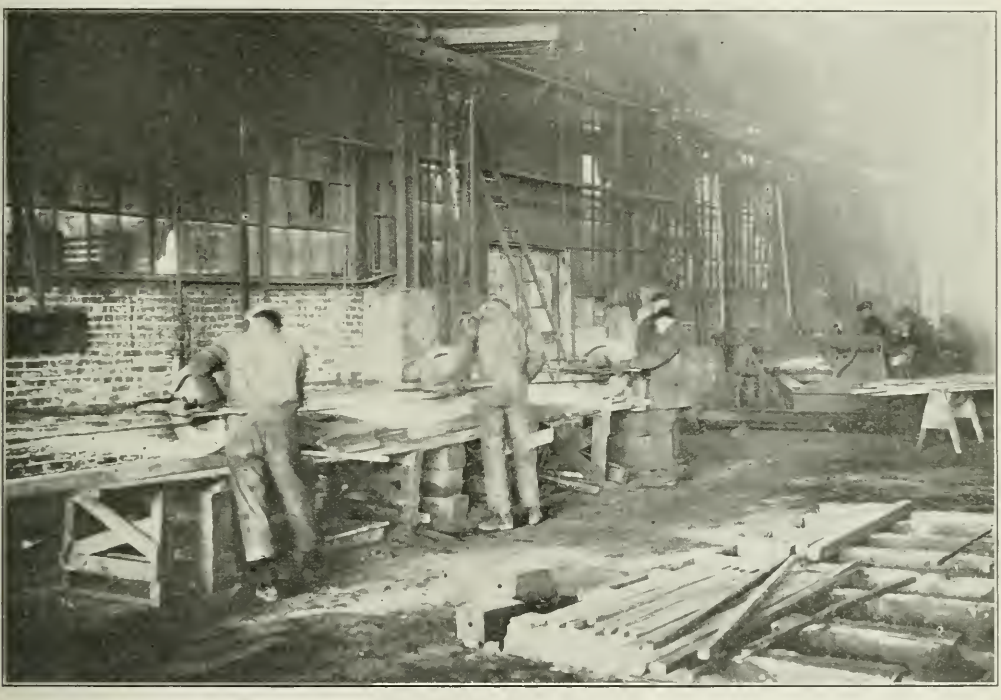


Fig. 2—A billet grinding room.

It is impossible to name a grain and grade of grinding wheel which will always give the most satisfactory and most economical results. A good average wheel for high speed billets is Norton grain 20 grade R Alundum vitrified and for high carbon steel grain 14 grade S Alundum vitrified. Exactly the right grain and grade and the right make of wheel for a particular set of conditions can be determined only after careful test.

Conducting a grinding wheel test involves careful record keeping and in order to be accurate it should be run for some time so that a fair average can be credited to each wheel tested. This is to allow for differences in pressure exerted by different operators and different weights of machines, or in other words to allow for the variable effect of the personal factor. It would perhaps suffice to measure the efficiency of the wheels by counting the number of tons of billets produced. It is possible to do this but a more accurate method is to weigh the billets before and after grinding, and determine the number of pounds of material removed by each wheel.

In determining the cost of grinding it will be found most convenient to divide it into three divisions, wheel cost, labor cost and overhead. The most accurate way to get at wheel cost is first to observe the average diameter at which stubs are discarded. The difference between the volume of the full sized wheel and the volume of this stub gives the volume of useful abrasive. This has cost the price of a full sized wheel. Dividing the cost of the wheel by the volume of useful abrasive gives the cost of one cubic inch. A test wheel can now be removed at any time and actual wheel cost computed by multiplying actual wheel wear by the cost per cubic inch.

It is best to remove the wheels at nearly the same diameter if possible. A wheel wears much faster as the size is decreased either because of lower peripheral speed or if the rpm be increased, because each particle is coming into contact with the work more often so that it is dulled and torn from the bond in a shorter time.

Labor cost can be figured by piece rate or by the hour.

Overhead is reckoned in many shops as so many times labor cost or so much per unit of production. For the present purpose it must be extracted from the Cost Department's records as so much per machine per hour so that it can be reckoned for the life of each wheel. This method also makes overhead a constant figure, that is, independent of the rate of production of the wheel when the workman is paid by piece rate. The overhead per machine per hour is sometimes hard to arrive at but is just as important as the other two terms of cost. What is desired is the total investment incurred by the grinding room (including supervision expense) and the number of pounds of steel removed by the wheels of each grain and grade. From these figures we can determine the cost of removing one pound of material. The wheel which removes material at the smallest cost per unit is, of course, the most economical wheel.

Let us see why it is necessary to take into account all these factors. Each department looks at the problem from a different angle. To the purchasing agent usually the most economical wheel is the one which lasts the longest. To the grinding foreman and the operator the best wheel is the one which cuts the fastest. To the Cost Department and the efficiency engineer the best wheel is the one which turns out a unit of production at the lowest cost, all items of cost being considered.

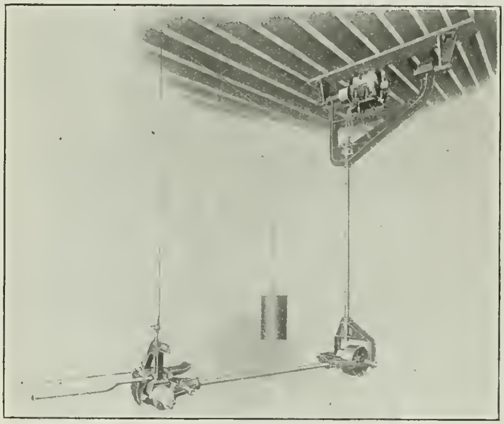


Fig. 3—A new swing frame grinder mounting the wheel on the end of the spindle instead of between the bearings. (Manufactured by the Safety Emery Wheel Company, Springfield, Ohio.)

There are a number of items to keep track of and the data sheet illustrated in Table A is suggested for this purpose. These figures are then transferred to a general data sheet Table B and results computed to show the cost per unit ground. This figure is then averaged for the wheels of each grain and grade. Objections are often offered to keeping so much data but it is really not much work. If the workmen are intelligent enough to weigh accurately each man can keep his own data sheet as shown in Table A. If they cannot be depended on the inspector can do it. The rest of the computation is not as complex as it may look.

In the example given it will be noted that with the wheel which lasted 36 hours and removed 72 pounds of steel the cost per pound of steel removed is $.49. This wheel is too hard and too slow cutting to be economical. The next wheel lasting 6½ hours removed only 22½ pounds of material and the cost per pound was $.49. This wheel was so soft that the particles did not remain in the bond long enough to cut efficiently. Wheel cost was excessive with not enough gain in speed of cutting to make it economical. The third wheel, while only of medium life cut at a very fast rate and removed material at a cost of only $.27 per pound. The saving in a year from finding a wheel which will perform in this way is worth many times the trouble of running the test.

Many foremen argue that all they want to know is how long a wheel lasts and how much it produces. That is not the whole story. What is required is the return which the grinding room is making on the money being invested in it. If the wheel is too hard it cuts slowly and, although the wheel cost is low, the labor and overhead expense are going on just the same and money is being lost. Furthermore if the wheel is too hard it will heat the work to such an extent that the seams, instead of being ground out are driven further into the billet. If the wheel is too soft the wheel cost is excessive even though production per unit of time is greatly increased. The problem is to find by experiment the wheel which gives the highest return on all items of investment.

There is another problem which to the writer's knowledge has not yet been solved. It is to determine the point at which it is more economical to give up chipping and remove the seams by grinding. It is generally believed that steels of more than 60 per cent carbon and all steels containing tungsten, chromium and manganese can be more economically ground. The problem could first be worked out with plain carbon steel and then with the alloys. It would take a great deal of experimenting, but would be very valuable knowledge. In arriving at a conclusion it should be remembered that the grinding wheel removes seams cleaner than does the chisel. The chisel tends to peen the seam over so that the workman is not sure he has gotten to the bottom of it. In the grinding method the seam is plainly visible until entirely ground out.

TABLE A.

Machine No.
Wheel
Size
Time Mounted
Time Removed
Hours Run
Diam. When Removed
Wheel Wear

Weight of Billet before Grinding	Weight of Billet After Grinding	Material Removed

TABLE B.

Wheel	Life in Hours	Diam. when Removed	Wheel Wear	Net Prod.	Material Removed	Cost	Labor	Overhead	Total	Cost per 1 lb. mat'l Removed
1	36	11½"	194	3.021 lbs.	72 lbs.	$4.42	$12.60	$18.00	$35.02	.49
2	6½	10	245	789 lbs.	22½ lbs.	5.58	2.27	3.25	11.10	.49
3	14½	11¼	203	1,825 lbs.	62½ lbs.	4.63	5.08	7.25	16.96	.27

Volume of Useful Abrasive—314 cu. in.
Overhead = $.50 per hour per machine.
Net price of wheel = $7.16 (16 x 2").

The Logic of Roll Design

General Discussion Pertaining to the Design of Rolls Employed in Mills Manufacturing High Carbon or Alloy Steels.

By W. H. MELANEY

PART VII

THE design of rolls for high carbon or alloy steels, such as high speed steels, is a matter of special interest as this differs in many respects from the methods employed in rolling low carbon steels, such as are produced by the ordinary merchant mill.

Roughing Rolls.

The same general type of roughing rolls are used for rolling high carbon steels as are used in the merchant mills with one exception. That is, that less reduction between passes is employed. This is due to two conditions: (1) The hardness of the steel due to its composition, and the lower heat at which most of it must be rolled, increases its resistance to elongation, therefore the spread is greater; (2) Due to its hardness and the fact that ragging the rolls is not permissible. As a result, the bite of the rolls is decreased and the consequent retarding of the entrance of the bar into the rolls is greatly increased.

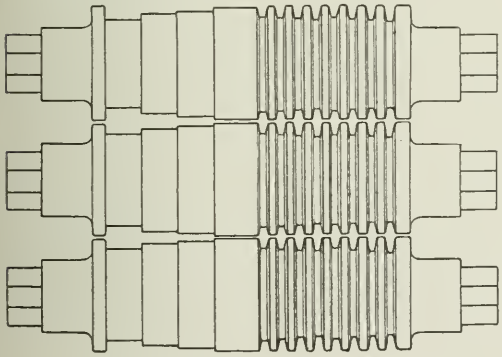


FIG. 1

Logical solution to overcome both of these difficulties is to have less reduction per pass. There is also a decided preference by most rollers to use all open square grooves in the roughing roll instead of the usual box passes used in the beginning of most merchant mill roughing. The reason for this is that the pressure on an open square groove is always toward the center from all four sides of the bar, thus reducing the size of the grain of the steel. In the box groove, the pressure is only from two sides and does not permit the opening up of the grain from spread.

It is pertinent to again call your attention to the previously stated fact that ragging on rolls for high carbon steels is always deleterious. It should never be resorted to because the effect of the ragging will show up on the finished bar as a surface defect.

In view of the conditions as stated above, a smaller billet is used on mills of this type than is used on ordinary merchant mills of the same diameter rolling soft steel.

Pony Roughing or Strands.

The same general type of roll is used for strands on hard steel as is used in rolling soft steel, however, the reduction from pass to pass is less. This is especially true on the reducing oval passes where if the reduction were as heavy as that used in rolling soft steels, the bar would not readily enter the pass and the end would become cold from the water used on the rolls. This would necessitate the cropping off of the end of the bar and as a result many delays and a general loss of tonnage would take place.

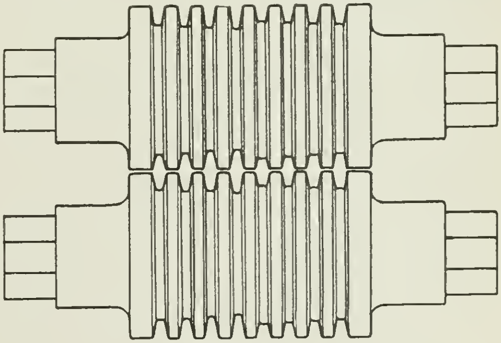


FIG. 2

Step and Edging Rolls.

From this point on, the design of rolls differs materially from those used in soft steel mills. Usually a set of three high step and edging rolls of chilled iron are used instead of the tongue and groove sand iron rolls, for rolling all sizes of flat steel. (See Fig. 1.)

On this type of rolls a square billet from the roughing or strand rolls is entered on one of the steps and is reduced on the successive steps to the required thickness necessary for entering the edging groove that will give the width of the bar to be produced. Either one or two edging passes are used to suit the prevailing conditions.

These edging grooves serve two purposes, to-wit, the standardizing of the width of the bar and due to the upsetting of the bar edgewise breaking off the scale from the sides of the bar and permitting a much smoother finish to be obtained after the bar has received a planishing pass through the chilled bull head rolls.

It will be observed that the bottom of the edging grooves are made of a shape to suit the edge of the bar desired either round or square edge. If a square edge is desired then the bottom of the edging groove is made convex as shown at A-Fig. 1, thus rolling the edge of the bar concave so that when the bar is subsequently planished through the bull heads the spread of the bar which on thin bars will be greatest in the center, will push out this concavity until the edge is square as intended.

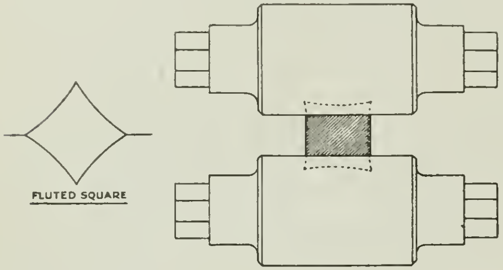


FIG. 3 BULL HEADS

It is necessary of course to have just the right amount of concavity to overcome the tendency of the bar to bulge or become rounded on its edge, due to subsequent reduction on the bull heads.

If a round edge flat is required, such as used on flat spring steel, then the edging groove is rounded at the bottom in the opposite direction as shown at B-Fig. 1 so that the edge of the bar will be convex, but as stated above, due to the bulging of the bar as the center of edge on subsequent reduction, the rounding of the edge in the groove must be less than that required on the finished bar. The sides of these edging grooves have considerable taper, usually 9 or 10 degrees, to permit of easy delivery of the bar and the necessary upsetting to crack off the scale from sides of bar.

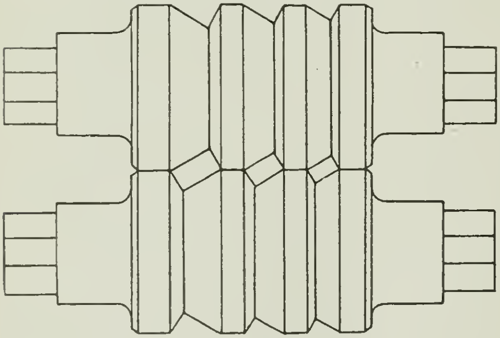


FIG. 4

After the bar comes from the edging grooves it is given one or two passes, depending on conditions, through plain chilled bull heads to reduce the bar to the actual thickness required.

On flat spring steel the last pair of rolls are turned to roll the bar slightly concave on top and bottom of the bar.

The advantage of the step and edging rolls is that a wide range of bars of different widths can be produced without the necessity of carrying a large stock of rolls as would be necessary if rolls of the tongue and groove type were employed, as the rolls can be raised or lowered within certain limits to produce a variety of widths.

Where absolute freedom of the edging rolls from interference with the step rolls is required a separate set of edging rolls are used in the stand that would contain the oval rolls in rolling rounds. (See Fig. 2) If rounds or squares are desired in high carbon steels they are rolled exactly the same as soft steels.

Thick Rectangular Bars.

In rolling thick rectangular bars with square edges where the thickness is but little less than the width of the bar two other methods may be used.

A given square is produced by the usual method except that all four sides are fluted or rolled concave as shown at Fig. 3 and this is then flattened out on the chilled bull heads to the proper thickness of the bar desired, the fluted edges taking care of the bulge that would otherwise happen on the edges of the bar and producing a square edged flat bar.

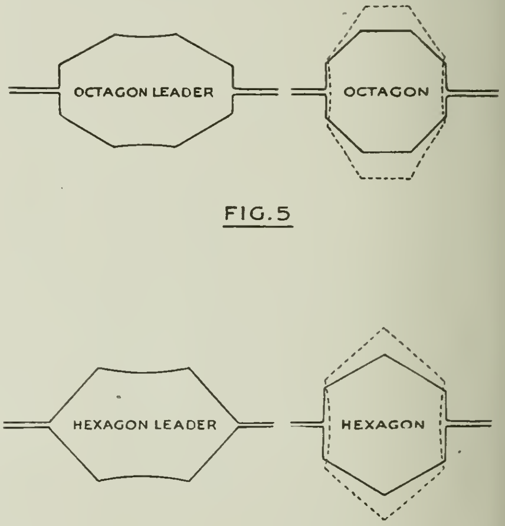


FIG. 5

Diagonal Flat Grooves.

The other method of producing a positive size of thick rectangular bar from a square is to turn the grooves into the rolls diagonally as shown at Fig 4. These grooves simply acting as flattening grooves and preventing any bulge on the edges giving a square edged bar of positive size. And no tongue and groove is required to roll this type of flat; it is needless to mention that chilled rolls are always used for this work, thus giving a smooth finish to the bar.

Hexagon and Octagon Bars.

Hexagon and octagon bars are rolled on the same principle as a guide round, except that the shape of the grooves is radically different. In other words, a square billet from the strands is passed through a leader groove, as shown at Fig. 5, for either the hexagon or octagon as desired and then edged up into the finishing groove to produce the shape wanted. The bar getting only one pass in the leader and one in the finishing groove.

You will note from the shape of these leader passes that four corners of either the hexagon or octagon are practically finished in the leader pass, the remaining corners in each case being finished in the finishing groove.

You will also note that the bottom of the leader grooves are made convex so that the bar will be rolled concave at this particular facet to allow for the bulge or spread when going through the finishing groove, as this particular facet will be opposite the break between the two rolls and if this were not done there would be a tendency to slightly overfill and cause the corners of the groove to mark this facet on the finished bar.

You will take particular notice that the finishing groove is divided in the rolls at the middle of one of its facets when it might just as well be divided at the corner between two facets, which is sometimes done, but the danger of getting a mark or overfill when divided at the corner is much greater than when divided at the middle of the facet, as all of the corners must be sharp and the groove perfectly filled.

There are no greater variety of shapes and sizes of bars rolled from high or alloy steel due to the numerous articles manufactured therefrom than are met with in mills devoted to rolling soft steel, and each one of them presents its own problems to the roll designer, but by applying the primary principles as outlined in this series of articles to the particular condition presented, little difficulty will be experienced in producing good results.

A great deal of high carbon and alloy steel is hand rolled, especially where absolute accuracy as to size and section is desired, therefore the tonnage of such mills is much less than that of the ordinary guide mill, rolling soft steel.

Low Temperature Carbonization and Its Relation to the Iron and Steel Industry

A Low Temperature Carbonization Will Only Prosper When Developed Along Similar Lines as the By-Product Coking Industry That Is Attached to Large Plants as a Supplementary Plant.

By A. THAU
Coke Works Superintendent, Oxelösund in Sweden

NEARLY 20 years have elapsed since Parker in England got first low-temperature carbonization protected by patents, as an initial effort to free the English cities, and in particular London, from the smoke and fog by removing from the coal used for domestic purposes its smoke producing constituents in subjecting it to low-temperature distillation. Compared with other industrial progresses, in particular with the closely related high temperature carbonization, the development in this special branch of the industry must be considered exceptionally slow. Though the facts upon which low-temperature carbonization is based had been recognized by way of research dating as far back as 1857, the practical application of the discoveries must be attributed to Parker who in 1915 took out a number of patents, for the exploitation of which the Coalite Company in London was formed which, after repeated failures and in spite of a very strong antagonism on the part of the English gas industry, is in England still in the foreground. Several other processes have since been exploited in the same country, but without an exception they have not been able to survive the trial stage.

In America as well as in Germany low-temperature carbonization had been taken up on a broad working scale just before the commencement of the war. The war gave fresh impetus to low-temperature carbonization in order to obtain as high a yield as possible from the coal, irrespective of the quality of the residue which at its best deserves its name, viz., "semi-coke." The two so far mentioned objects underlying low-temperature carbonization, viz., the production of a smokeless easily ignited fuel and valuable oils, are supplemented by a third, viz., the economical utilization of a fuel rich in volatile matter which is not suitable for the production of metallurgical coke or as a steam or house coal. These three different directions dominate low-temperature carbonization respectively in the three countries named, in which it is mainly adopted. In England the production of a smokeless fuel stands in the foreground without, however, losing sight of the profits derived from the liquid hydrocarbons which the process yields so abundantly. In the United States the profitable carbonizing of certain classes of coal has been the main purpose to develop low-temperature carbonization to an accomplished process, while in Germany the recovery of the oils stands mainly and solely in the foreground. The unfavorable rate of exchange makes it very difficult to import mineral oils or gasoline into Germany on an extensive scale and thus the low-temperature carbonizing processes are destined to fill a serious gap.

In consequence of these different aims upon which the same process is based in each particular country can a very wide variation in the design and working methods be noticed. In England the intermittently working vertical retort, either made of cast iron or of refractory material, has been adopted by the Coalite Company. In America the continuously working horizontal retort in connection with a briquetting plant and inclined intermittently working high temperature retorts, both built of refractory material, have been given preference in the most successful plant, viz., the Carbocoal process. In Germany the continuously working revolving steel retort has been almost universally introduced, probably on account of the fact that its design as applied to cement works and for roasting ores did not offer anything altogether new in the way of constructional details and obviated extensive experiments for which there was no time during the war. In comparing these three different methods by which the same process is explored, it becomes by the lack of uniformity apparent why the development has been so slow and why the iron and steel industry has been so reluctant in adopting low-temperature carbonization as one of its side lines like, for instance, by-product coke ovens or gas producers.

There is no doubt that the Coalite process in England is best adapted for its main aim, the production of smokeless fuel of lumpy nature. On the other hand does it become evident that the units of the Coalite plant are not designed for a large output of fuel. The retorts are small and if one considers that a battery of 20 retorts is required to deal with a daily quantity of only 60 tons of coal, there is no doubt that to deal with quantities nearing the consumption of even a middle sized industrial undertaking, a plant of great magnitude becomes necessary.

In Germany large quantities of fuel can be treated in a comparatively very small unit with continuously rotating retorts made of steel plates. The disadvantage in these processes, however, rests with the fact that while the coal is subjected to a very intense heating, without endangering the yield of liquid hydrocarbons by pyrogenic decomposing, the formation of coke is at the same time largely prevented and the residual product cannot easily be utilized.

The weak points of both these carbonizing plants have been overcome by the American Carbocoal process in which it is not attempted to make a suitable coke in one operation. The coal is first subjected to a continuously working low-temperature carbonizing process with the sole aim to obtain a high yield of liquid hydrocarbons, to pass large quantities of coal through comparatively small and automatically working units and the quality of the semi-coke is in the first place disregarded entirely. To convert it into a marketable product, it is afterwards briquetted with an addition of pitch and again carbonized so that the briquettes differ from all others in that they do not consist of a mixture of carbon and pitch, but have a quite homogenous texture.

The fact that the statements and promises put forward by low-temperature carbonizing undertakings have had a rather sceptical reception in most quarters is in no small measure due to the unnecessary secrecy into which these processes have been enveloped and which has done more harm than is generally realized by their promoters. Great credit is due to the Carbocoal Company for having abandoned this harmful practice by giving their system of operation wide publicity and insight into the smallest details by throwing open the gates of their plants for the closest inspection to interested parties.

When low-temperature carbonization was first planned on a working scale in England, it was planned as an adjunct to domestic gasworks. It was intended to supply a rich gas, high in calorific value and great illuminating power to enrich cheaper gases which might be advantageously produced in the gasworks, such as water gas, etc. The sales of the semi-coke would cover the cost of the coal while the oils and ammonia would, together with the price obtained for the gas, pay for the plant and its upkeep, leaving at the same time a large margin as profits. The proposition was sound enough from the start, but the scheme was doomed to failure from the beginning for the simple reason that the plants were erected on a large scale before the experimental stage of the process had been passed. Experimenting with plant on a manufacturing scale has rarely led to profitable results and in addition the English householders were very reluctant in using the friable semi-coke. They would rather put up with a few foggy days and stick to their coal. In consequence the large plants had to be pulled down again after hardly one year's working and this fact left such a deep impression upon the otherwise very progressive English gas industry that its engineers have given up for ever taking low-temperature carbonization seriously. All progress made since then, all the many lectures of educational value in this field, all efforts to convince the gas industry that developments have since been reached which would justify a renewed co-operation are promptly rebuked by the English gas industry, irrespective of the fact that low-temperature carbonization people have been able to win very prominent scientists and gas experts as powerful promoters for their aims and ideas, such as the late Prof. V. B. Lewis, Prof. Armstrong, Prof. Bone and others.

Since it is apparently not possible to overcome the deep rooted prejudice of the gas works, the Coalite Company has been compelled to direct its efforts towards the large iron and steel industry to seek an outlet for the coal gas and possibly for the coalite yielded as a residue. A plant has been erected at Barnsley in Yorkshire where the surplus power is converted into electric energy and the coalite gasified in producers. Though this represents the largest low-temperature carbonizing plant in England, its size hardly exceeds that of a fair sized experimental station and until quite recently it has served more or less for that purpose. Still one must admit that the most important experiments have found a satisfactory solution and the process can now well board upon industrial lines without fearing the former disastrous experience. The present juncture seemed to be favorable for the extension of low-temperatue carbonization in England on account of the gasworks being at liberty to abandon the former parliamentary standard for the quality of the gas based upon its candle power and to substitute a certain calorific value which in some cases, particularly in the Sheffield steel district, is inferior to the former quality. A number of industrial undertakings in Sheffield using gas in their industrial plants objected very strongly to a reduction of the calorific value and threatened to enter into combination with a low-temperature carbonization process for the supply of their gas. Several extensive schemes are in contemplation to supply a certain part of the industry with the rich low-temperature gas at a moderate price, but for a long time nothing further has been heard of these proposals and their realization. There is no indication as yet that the iron and steel works in England have taken up low-temperature carbonization on their own account as a side line.

In Germany, low-temperature carbonization has, as already mentioned, supplemented the deficiency of lubricating oils and gasoline. The process had been taken up scientifically first just before the war and has since made great progress, particularly in the lignite and shale districts. In the coal fields its development is as yet not so pronounced since there is a conspicuous absence of cannel or other bituminous coals high in volatile matter, and what there is is readily swallowed by the extensive by-product coking or gas industry if it has not to be supplied to the former enemies in accordance with the peace treaty. Thus only a comparatively small amount of ordinary gas coal is being treated by low-temperature carbonization in the plants of which are attached to iron and steel works. The retorts are heated by blast furnace or producer gas while the rich low-temperature gas is used in open hearth furnaces, in iron mixers or in roasting furnaces. Particularly for the heating of revolving furnaces preference is given to a low-temperature gas on account of the great heating value concentrated in a comparatively very small gas volume. By using such rich gases as a heating medium, the suspension of dust, which is very conspicuous in kilns heated with blast furnace or other lean gases is very much retarded owing to the small amounts of flue gases which are being formed. The semi-coke is of rather poor quality, very friable and containing a very high percentage of small dust. It is either used as a fuel for producers or utilized as powdered fuel, for which purpose it must be mixed with a certain proportion of bituminous coal Owing to its low specific gravity it might make a good colloidal fuel if mixed with certain oils, but the writer is not aware that trials in this direction have so far been made. Besides the yields of oil, great attention is being paid to the recovery of ethylene, of which the contents in low-temperature gas are comparatively high compared with coke oven or domestic coal gas.

In America again low-temperature carbonization is established as an industry of its own. The carbocoal plant at South Clinchfield in West Virginia is the largest low-temperature carbonization plant in the world and differs from all others in that the coke residue, the carbocoal, can be readily utilized in the iron and steel industry so that the process is not solely dependent upon householders as fuel consumers. Figures have been published as to the efficiency of carbocoal when burnt under boilers, in locomotives and as fuel for water gas producers, all of which were distinctly favorable. The possibility of using carbocoal in industrial furnaces was propounded and it would be very interesting if further results in this direction were published. According to the tests which the writer was able to make with single pieces of carbocoal, there appears to be no reason why it could in many instances not take the place of metallurgical coke if its price can stand the comparison. I am, however, of the opinion that for an effective use in the blast furnace, the carbocoal briquettes ought to be of larger size, so as not to form too dense a burden and to give more free space and less resistance for the wind to travel. In a cupola the carbocoal briquettes in their present size and shape and with their high density and crushing strength ought to serve excellently.

It has already been mentioned that the carbocoal people can take credit for having removed the veil of secrecy from low-temperature carbonization as far as their process is concerned. To convince the professional sceptic they would further serve a good purpose if they could see their way clear to supplement their statements by publishing a heat balance sheet of the whole plant. To the outsider it must naturally appear that a double carbonizing of the coal must require an excessive amount of heat quite apart from the heat required for steam raising, generating of electric power and for the distilling of the tar. The figures so far published are not quite clear upon this most important point of heat economy and require to be supplemented.

Still it is no small achievement that by this process for the first time a readily marketable fuel is being produced and the economy of such a plant may perhaps be considerably increased if it could be attached to other works where surplus heat in the form of gas is available and where the rich low-temperature gas as well as the fuel may be advantageously consumed on the premises.

The writer has been intimately connected with low-temperature carbonization for many years and has followed up its development very closely and has come to the conclusion that low-temperature carbonization has not much chance to prosper as an isolated or independent industry of its own. It will, in the writer's opinion, prosper and develop on similar lines like the by-product coking industry, if attached as supplementary plants to other large works which interchange the gas and take up the fuel and which for this purpose must be closely interconnected with the low-temperature carbonization plant.

Such plants can supplement large works in many directions by supplying heat to their particular manufacturing processes such as iron, steel and other metal works, ceramic works, power plants, etc. The idea has often been advanced to stop the use of raw coal in open fires altogether and to use coke or a coal from which the valuable hydrocarbons have been removed by distillation, or to heat solely with gas. Suggestions of that kind are too broad altogether and even if possible to carry them though would require such enormous alterations to existing plants or methods that it is quite unreasonable to preach in earnest such radical changes. On the other hand it has been proven often enough, but is not sufficiently known, that a given amount of fuel, gasified completely, does not give the same efficiency on, for instance, a steam boiler as if this amount of fuel was fired direct. An improvement of the efficiency under these circumstances might, however, be reached if the coal is subjected to low-temperature carbonization, the semi-coke be gasified in producers and the low-temperature gas be mixed with producer gas which thereby gets somewhat enriched. The proposition is not new and is put into practice at the already mentioned Barnsley power plant by the English Coalite Company.

The efficiency of a plant as just described irrespective of the low-temperature coking system applied for generating electric power could be still raised considerably if the gas generated was used in gas engines and the least valuable part of the tar oils in Diesel engines. By supplementing the varying power demands during certain hours of high load by the Diesel engines a very favorable load factor could be maintained on the gas engines in average.

In conjunction with iron and steel works, where the requirements for heat and power are more even, an equally good efficiency can be obtained without having to use the tar oils on the spot. There is no doubt that the very slow development of low-temperature carbonization is due to the fact that it is difficult to dispose of the semi-coke, owing to its inferior condition, and upon the disposal of the residue the whole economy of the plant must necessarily depend. If the general industry can utilize this fuel to advantage, then the progress is assured, but, as already said, only if the plants form an adjunct to large works, thus obviating an extensive transport of the residue.

Another kind of low-temperature carbonization must be mentioned in this connection which was largely introduced into Germany during the war and greatly assisted in relieving the acute scarcity of mineral oils for lubricating purposes. Instead of passing the coal first through a low-temperature carbonizing plant and transfering the remaining semi-coke to gas producers afterwards, the same effect is obtained in one operation with greater economy. In the producer are—depending upon its diameter—suspended from above one or several vertical iron retots which reach with their lower end close to the fuel bed inside the producer. The coal is fed through these retorts continually and by the hot producer gas surrounding the retorts and partly traveling upwards though the coal, low-temperatue distilling is effected. The gases escaping on top of the feeder retorts are conducted through separate plant, freed from the oils which are carried forward with the gas in form of vapor and then the gases are mixed with the producer gases proper which escape through the usual offtake. This arrangement offers the advantage that existing producers can without great costs be converted for this purpose and a better efficiency is obtained in that the glow heat with which the coke arrives on top of the fuel bed is preserved for the producer and in addition there is naturally less dust in obviating a cooling and handling of the soft semi-coke. As promising as this arrangement looks and although it has been widely adopted, the opinion about its advantage differs greatly and the reports heard are so contradictory that the writer has so far been unable to form a proper judgment of the process with which he has not been in personal contact.

The conclusion which a close observer must draw from the development of low-temperature carbonization so far tends to show that a further growth can only be expected by a close co-operation between low-temperature process and the iron and steel industry in general. The latter, however, has hardly paid sufficient attention to the possibilities and advantages which these processes may offer in the form of supplementary plants under proper conditions.

Blast Furnace Flue Dust—100% Recovery

Present Methods of Gas Washing and Flue Dust Recovery Coordinated to Accomplish Complete Recovery and Recharge of All Flue Dust at Blast Furnace—Wash Water Evaporated at Slag Pit.

By GEO. B. CRAMP

IN THE March, 1921 issue of "The Blast Furnace and Steel Plant" there appeared an article, under similar headline and by the same author, dealing with the direct recovery of blast furnace flue dust by application of present practical methods of recovery, which properly arranged and coordinated would accomplish direct recovery and recharge of over 90 per cent of all the flue dust produced at the blast furnace; a graphic arrangement of the proposed apparatus appearing with the description.

In this paper and accompanying drawing, it will be attempted to show the practicability of the installation of such a flue dust recovery plant as above referred to, at the average modern blast furnace plant, and it will be further shown that by the addition of a simple cooling system for cooling the over flow water from the sludge settling tanks so that it may be recirculated to the gas washer; practically a 100 per cent recovery of flue dust is effected and complete disposition of the corrosive water, resulting from recirculation, made possible by pumping it to the slag granulating pit where it is vaporized by the hot slag or absorbed by and removed from the slag pit with it, thus preventing contamination or obstruction of public water courses that result from the practice of allowing gas washer water to run freely into these bodies of water.

Figures will be presented to show that even though the sludge settling tanks may effect the recovery of as much as 98 per cent of the flue dust contained in the entering gas washer water, the power cost of cooling the overflow water for re-circulation is easily covered by the 2 per cent of flue dust remaining therein; its recovery by this means being fully justified.

As the method of sludge recovery and recharge into the blast furnace, as previously outlined and herein represented, may in some respects appear novel, or even radical, especially as regards the introduction of apparently considerable quantities of moisture into the blast furnace, figures will be given to show that the moisture entering the furnace with wet flue dust in sludge form is not excessive.

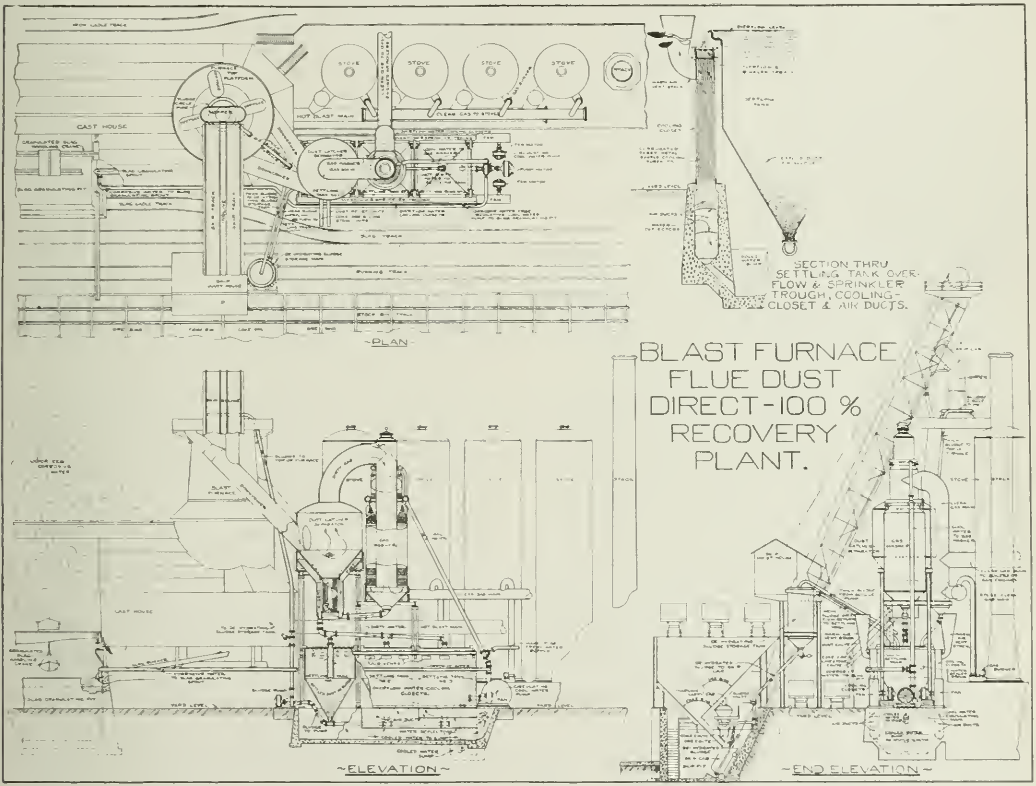
The proposition of cooling the overflow water as herein outlined, and re-circulating it through the gas washer, is,—as applies to blast furnace gas washing,—a somewhat decided departure from past or even present day practice, but the same system is followed in by-product coke plant operation at the final coolers, where water having once been used in direct contact with coke oven gas to accomplish cooling, it itself cooled and re-circulated again and again through the final coolers; losses by evaporation in cooling the water being restored by make-up, or fresh water from the supply lines. By this means contamination of public water courses is avoided at the by-product plant, and the same method will prove applicable to the control and disposition of dirty gas washer water at the blast furnace.

The apparatus in detail and operation described in the previous article above referred to, consisted of the dust-catcher-separator, the gas washer, the sludge settling tanks, and the sludge pump, all of which are represented in the drawing accompanying this paper. The added features shown and described herein are the overflow water sprinkler troughs, the overflow water cooling closets, air ducts and motor driven fans, the individual cooled water circulating pump, the piping system to the gas washer and slag granulating pit and the de-hydrating sludge storage tank with its sludge feed and weak sludge return pipe to the settling tank and the de-hydrated sludge pipe to the skip pit, all being in relatively correct position in plan and elevation.

Direct 100 Per Cent Recovery of Flue Dust Described.

Gas from the top of the blast furnace enters the dust-catcher-separator through the downcomers. In the separator the velocity of the gas is greatly reduced, the dust carrying capacity of the gas being also greatly decreased as a consequence and all the heaviest solid particles in the gas are dropped into the bottom of the separator, the arrangement of which accomplishes the separation of coke, ore and limestone,—that may come down with the gas during furnace slips,—from the fine dust which later is flushed out of the dust-flushing-well in the bottom of the separator, by the same water that has previously been used in the gas washer. The bulky stock is held in the separator away from contact with water until removed through a properly constructed gate and chute which latter is provided with a grated bottom permitting any dust that may come out with the larger stock to drop immediately into the settling tank through a chute projecting into the water contained therein. A dust relief pipe may be provided to take off accumulated dust from the dust flushing well in case water goes off the gas washer and the dust flushing feature is thus rendered inoperative.

The dust-catcher-separator thus permits all dust brought down in the gas-cleaning operation to be gathered together in one wash water which may be disposed of as later described.


STOVE
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SECTION THRU SETTLING TANK OVERFLOW & SPRINKLER TROUGH, COOLING-CLOSET & AIR DUCTS.
BLAST FURNACE FLUE DUST DIRECT-100 % RECOVERY PLANT.
BLAST FURNACE
CAST HOUSE
~ELEVATION~
~END ELEVATION~

Fig. 1.

The Gas Washer.

Here the gas is cooled and the dust washed out by contact of the dirty gas with wet baffle surfaces, the arrangement of which may be similar to that described in the earlier article on this subject. The spacing of these baffles must conform to water distribution over them, which in this recovery and circulating system should be maintained at a minimum so that the velocity through the settling tanks will be as low as possible in order that precipitation of flue dust therein will be complete or nearly so, leaving a minimum dust content in the overflow water. Any approved type of gas washer however, may be used in connection with this recovery system.

Cooled Water Circulating Pump.

This pump, instead of being located at a station some distance from the furnace plant, is located with the recovery plant at the blast furnace where it picks up the cooled overflow water out of the cooled water sump,—which water may contain from 1 to 10 per cent of the dust it contained on entering the settling tanks. Even though this dust content of the cooled overflow water may be constantly as much as 10 per cent, it will offer no serious obstacles to recirculation of the water through a properly designed and constructed circulating pump. By recooling and recirculating the gas washer water in this manner, whatever dust remains in the overflow water from the settling tanks is kept in circulation until it returns again to the settling tanks where it is eventually precipitated, thus preventing the loss of any dust which would occur in considerable quantities when the overflow water is permitted to run to the sewer, or a nearby stream.

The location of the cooled water circulating pump at the recovery plant offers an additional advantage in providing for disposition of the wash water after its continued reuse when it becomes impregnated with corrosive elements which make its continued recirculation undesirable, unless diluted by additions of fresh water, which operation will be more fully dealt with later.

The Settling Tanks.

These tanks are of square inverted pyrimidal shape to provide the greatest capacity in a given space. They have steep pitched bottoms which permit the settled dust in sludge form to be uniformly removed therefrom, through the sludge pipe connections on the bottoms of the tanks.

Dirty wash water from the gas washer enters the tanks through a gas seal pipe projecting into the center of each tank. The total quantity of water is divided into three equal parts by the dirty water piping arrangement. One part enters each tank at the center and flows at a decreasing velocity to the overflow weir walls of the settling tanks, the precipitation of over 90 per cent of the original dust content of the entering wash water being thus accomplished.

For a blast furnace with a 24-hour daily output of 600 tons of pig iron, in the production of which 150,000 cu. ft. of gas per ton of iron is made, and a total of 90 million cu. ft. of gas produced, which requires 62,500 cu. ft. of gas to be cleaned per minute; there is required 1,600 gallons of wash water per minute at 25 gallons of water per 1,000 cu. ft. of gas to be washed.

Dividing this quantity of water into three equal parts, there would be a flow of 534 gallons of dirty water into each settling tank per minute. Space at the modern furnace plant would not permit of a much larger settling tank than 20 feet square with a capacity each of about 60,000 gallons which would permit all water passing through it at 534 gallons per minute to be retained therein approximately one hour and fifty minutes. This retention period should accomplish close to a 99 per cent precipitation in the settling tanks if this retention period is not reduced by increased water flow through the tanks: but as the tanks become partly filled with settled flue dust and the quantity of water circulated is increased,—as will be necessary in extremely warm weather,—the water will be retained a much shorter period and a lower rate of precipitation will occur.

Overflow Water Cooling Closets.

The purpose of the cooling closets is to cool the overflow water from the settling tanks in order that the water with its low dust content may be sufficiently cool to reenter the gas washer where it will again perform the operation of properly washing and cooling the gas.

The closets are shown in cross section in the enlarged insert on the drawing, and may be composed of corrugated sheet metal baffles to afford the proper cooling surface. These baffles are arranged directly under the sprinkler troughs into which the overflow water from the settling tanks flows. The bottoms of the sprinkler troughs are perforated with ¼" diameter holes being placed in rows aligned over each baffle sheet. The water falls through these holes in a solid stream which is broken up and distributed over the baffles on contact with them. The air which is forced through the air ducts and up between the baffles, by the motor driven fans, flattens the water against the baffle surfaces down which it flows, giving off the heat it contains to the air traveling in the opposite direction. The air passes out of the cooling closets by way of the warm air vent stacks with all the heat the water had held on entering the coolers, while the water leaves the closets at close to wet bulb temperature of the atmosphere.

The cooled water from the cooling closets drops into the air ducts directly under them, being deflected to the sides thereof by the water deflectors, and from thence the water flows into the gutter and on into the cooled water sump from whence it is lifted by the circulating pump to the gas washer.

The cooling closets run the full length of the three settling tanks on both sides, and for the maximum quantity of water to be cooled, need not be wider than 30 inches with an effective baffle height of about 15 feet and 4 inch spacing which will require no additional space for installation much in excess of the area occupied by the tanks themselves. At furnace plants where a tank 20 feet square could not be installed the tanks could be narrowed and lengthened or preferably increased in number.

There are doubtless more efficient cooling systems than that just outlined, but they are not so well adapted to conditions existing about the average blast furnace plant. One system of efficient water cooling is the spray pond, but it could hardly be made to operate to its highest efficiency possible on the comparatively low head existing between overflow and ground levels, while even the low dust constant of the water entering the spray pond would eventually fill it up necessitating its cleaning and the requisite space for its installation could not be found near the blast furnace.

Other tower coolers of greater efficiency are usually of too great a height to secure entry of water into their water inlets at the head available, making necessary their installation too far below ground level to be practicable. It would not be well to raise the tanks and other apparatus because sufficient drop of the downcomers from the blast furnace could not be secured at the average blast furnace, it being necessary to provide a good downcomer pitch to insure their self cleaning features.

The continuous requirement of 35 hp for driving the fans supplying air to the cooling closets is entirely justified by the saving in flue dust accomplished by this cooling and recirculating system, as will appear by the figures presented in the following:

From the average blast furnace there is blown with the gas about 200 lbs. of flue dust per ton of pig iron produced and on this basis a 600-ton furnace would lose 60 tons of flue dust per day. If as much as 98 per cent of this dust is recovered by ordinary processes of gas washing and flue dust recovery, there is a loss of 1.2 tons of flue dust represented in the 2 per cent that has escaped recovery. The metal equivalent of this lost dust at 50 per cent metallic content of flue dust is 0.6 tons which at $20.00 per ton for pig iron is worth $12.00. The cost of 35 hp for 24 hours at as high as 0.7 cent per horsepower hour would be about one-half the value of the lost flue dust, leaving a margin of $6.00 per day in favor of the power driven cooling system, while contamination of public waterways is effectively prevented, and litigation often resulting from such stream pollution entirely avoided.

When the efficiency of the recovery system is materially reduced by increased water flow through the settling tanks, the saving in favor of the power driven cooling system becomes relatively greater.

Corrosive Water Disposition.

Repeated circulation of water through the gas washing system, as already stated, will cause the water to become increasingly corrosive, necessitating its constant dilution and disposition. This is accomplished in this system by opening and closing the proper valves in the cool water lines at the outlet of the cool water circulating pump, and without stopping the pump, directing a stream of corrosive water to the slag granulating pit and permitting fresh or make-up water to run direct to the gas washer; this operation taking place during the tapping of slag from the blast furnace.

At most modern furnace plants a slag granulating pit is provided at, or near the furnace, into which hot slag is run and granulated by projecting a stream of water against the hot slag stream from under and behind it, just as it flows from the runner or spout into the slag pit. This causes the slag to break up into granules and become very porous. The hot slag in this operation drives off considerable water in vapor form and because of its great porosity when granulated absorbs considerable water, the actual quantities involved appearing in the following:

In the production of one ton of pig iron by the blast furnace there is produced about 1,300 lbs. of hot slag. This slag when granulated and free of moisture weighs about 26.5 lbs. per cu. ft. In the cooling and granulation of each cubic foot of this slag there is required about 2.0 gallons of water which is driven off in the form of vapor, while each cubic foot of slag absorbs about 2.3 gallons of water which is removed from the granulating pit with the slag by the slag handling crane. Each 1,300 lbs. of hot slag produces 50 cubic feet of granulated slag and at the above rate of water consumption per cu. ft. of slag granulated, there would be a total of 215 gallons required for each 1,300 lbs. of slag or each ton of pig iron produced. Thus at a furnace producing 600 tons of pig iron daily, 129,000 gallons of water are required at the slag pit.

There is in the settling tanks and circulating system a total of 180,000 gallons of corrosive water that must be tempered or diluted and continually disposed of. At the rate of but 1,600 gallons of water circulated per minute, this quantity of water comes into circulation about 14 times each 24 hours and as there is a water loss by evaporation, each time the water comes into circulation, of about 1 per cent, there would be a total daily loss of 14 per cent of 180,000 gallons or 25,000 gallons which with a disposition of 129,000 gallons possible at the slag pit would make a total of 154,000 gallons of water disposed of daily.

From this figure however must be deducted the condensed moisture coming from the gas washing or condensing operation, which may be determined about as follows:

Roughly an average of 650 lbs. or 77.0 gallons of water is driven out of the furnace with the gas for each ton of pig iron produced and a furnace of 600 tons would in this manner produce an average of 46,000 gallons of water daily, which comes into the circulating system in the gas washer. Consequently the net corrosive water disposition will be the difference between 154,000 gallons and 46,000 gallons, or 108,000 gallons daily.

The original contents of the circulating system having been stated to be about 180,000 gallons it will be seen that a complete renewal of the circulating water is possible every two days, but during this period the water is diluted by frequent additions of fresh or make-up water at slag tapping periods. Thus a minimum of corrosive elements is maintained in the water.

No reference has been made to moisture contents of the sludge entering the blast furnace in the foregoing, because such moisture is returned again to the blast furnace in form of wet sludge and no additions of water to the circulating system will take place from this operation.

This system of corrosive water disposition besides preventing the fouling of water courses, is well adapted to blast furnaces operating on ores high in valuable alkalies. These alkalies coming off with the furnace gas are taken up by the circulating water, but instead of being disposed of at the slag pit, this water with its valuable alkaline content may be piped as needed to a leaching or evaporating plant for the recovery of these alkalies.

Flue Dust Recovery and Recharge.

Flue dust in sludge form is drawn from the bottom of the settling tanks through a pipe line to a sludge pump of special design. This sludge pump may lift the sludge direct to the top of the furnace where it is distributed uniformly through properly constructed nozzles. This sludge may contain from 35 to 50 per cent of its own weight in moisture above its saturation point which is about 15 per cent of its own weight of water, making a total moisture content of from 50 to 65 per cent, and though the charging of so much moisture may seem impracticable, figures and comparisons will be given later to show that this moisture is negligible compared to the large fluctuations in moisture contents of the raw materials charged into the furnace in the usual manner.

The above moisture content of the sludge may, however, be reduced 10 to 15 per cent by pumping the sludge to the de-hydrating sludge storage tank located near the skip pit, as appears in plan and elevation on the accompanying drawing. This tank is of comparatively deep depth and sufficiently large to hold one day's production of flue dust. The sludge is pumped through a pipe line entering the center and top of the de-hydrating tank. The heavy particles immediately settle to the bottom and, as the depth of the sludge increases, it displaces some of the water contained therein, which rising to the top, overflows in the form of thin sludge and is returned to one of the settling tanks for resettlement and recovery of its dust content.

The location of the de-hydrating tank at the skip pit permits the operator of the stock charging larry car to drop a charge of de-hydrated sludge into the skip car by opening the quick acting sludge valve to which he has access when his larry car is in the dumping position over the skip car.

Thus the thick sludge may be charged by the same means that all other raw materials are charged into the blast furnace, or if it may be desirable to transport sludge from the de-hydrating tank to a sintering plant or stock pile it may be dropped from this tank directly into a standard gauge car.

Flue dust charged into the blast furnace by either of the above described methods cannot be blown immediately from the furnace, and helps wet down other stock and reduces dust production in charging. It is possible, of course, that the moisture in these materials is soon driven off, leaving the dust free to be blown again from the furnace. The production of flue dust however cannot be completely cumulative, i. e., all flue dust so charged cannot possibly be blown from the furnace along with the usual quantity that would have been produced even had the flue dust not been recharged. Gas volumes and velocities determine the amount of dust produced and a given volume of gas at a given velocity will carry a definite and fixed burden of dust and cannot be made to carry more unless the velocity is increased.

Granting, however, that the dust production will, by this method of recharge, be somewhat greater than in the usual furnace operation; any additional dust that may leave the furnace is simply recovered in the usual manner and returned again to the furnace.

This system of recovery permits of a more accurate accounting of the materials charged into the furnace, because there will never be any unaccounted for losses such as occur now, where ineffective recovery of flue dust or no recovery at all is the practice.

Moisture Considerations of Recharged Flue Dust Sludge.

What may appear to be excessive moisture contents of the sludge recharged into the furnace in this system of recovery is here considered, a table of moisture contents of raw materials entering the furnace to produce one ton of pig iron being first presented.

		Weight of Moisture Contents.		
Materials.	Weight.	Minimum.	Maximum.	Average.
Iron Ore	4,400 lbs.	375 lbs.	1,010 lbs.	575 lbs.
Coke	2,200 lbs.	22 lbs.	250 lbs.	55 lbs.
Limestone	1,100 lbs.	11 lbs.	40 lbs.	16 lbs.
Totals	7,700 lbs.	408 lbs.	1,300 lbs.	646 lbs. = 77 gals.

Between the total maximum and minimum moisture contents in the above table there is a difference of 892 lbs. of moisture, and between the maximum and average totals 654 lbs.

These wide variations in moisture contents of the raw materials entering the furnace are caused largely by changeable weather conditions to which the materials are exposed before charging into the furnace. As great as these moisture variations are, however, they occur without serious interference to any of the furnace or gas washing operations.

From 7,700 lbs. of raw materials entering the furnace, an average of 200 lbs. of flue dust is produced. If to this flue dust is added as much as 65 per cent moisture to accomplish hydraulic charging, the amount of water entering the furnace from this source would be 130 lbs. which is about 1/7th of (892 lbs.) the difference between maximum and minimum moisture content of materials entering the furnace, and 1/5th of (654 lbs.) the difference between maximum and average moisture contents.

As it is possible to charge the flue dust by way of the de-hydrating tank and skip car with a considerably lower moisture content than that stated in the foregoing examples, the moisture content of the recovered sludge should offer no deterrent to its being charged by either of the methods suggested.

Other Considerations.

It has long been considered absolutely necessary by many blast furnace operators that flue dust be sintered, nodulized or briquetted before attempting to recharge it into the blast furnace. In the early days of the use of soft, fine or dusty Messaba Range ores, such difficulties were encountered in their satisfactory reduction and so much flue dust produced in the operation of the furnaces then existing, that it was almost generally believed for a time, that these obstacles were only surmountable by sintering or briquetting at least some portion of the fine ores composing the furnace burden, or by using a certain amount of lump or bulky ore along with the fine ores to be reduced. Developments since that time have shown however, that these difficulties were not overcome by treatment of these ores, or use of bulky ore, but almost entirely by better furnace practice and improved design, and in this direction,—no doubt,—lies the complete solution of the blast furnace flue dust recovery problem.

The idea of sintering or briquetting flue dust is to provide, if possible, a bulkier and harder product that will not be carried from the furnace in charging or in normal furnace operation; and which will of itself help maintain a more open or porous condition of the furnace burden than is possible if the raw or untreated flue dust is recharged into the furnace.

The tables showing the comparative weight and bulk of all materials entering the furnace here follow, with the object of showing how small a part of the whole furnace burden flue dust composes, and how little this dust, if immediately sintered and recharged continuously as produced, will add to the openness or porosity of the whole burden.

Materials.	Weight.	Wt. per cu.ft.	No. of cu.ft.
Iron Ore 55%....	4,400 lbs.	150 lbs.	29.3
Coke	2,200 lbs.	35 lbs.	62.8
Limestone	1,100 lbs.	95 lbs.	11.5
Totals	7,700 lbs.		103.6 cu.ft.

By Wt. Iron Ore composes 57 hundredths of the total Wt. of materials charged.

By Wt. Coke composes 29 hundredths of the total Wt. of materials charged.

By Wt. Limestone composes 14 hundredths of the total Wt. of materials charged.

By Bulk Iron Ore composes 29 hundredths of the total Bulk of materials charged.
By Bulk Coke composes 60 hundredths of the total Bulk of materials charged.
By Bulk Limestone composes 11 hundredths of the total Bulk of materials charged.

There is produced, in the operation of reducing each 7,700 lbs. of the above materials to one gross ton of pig iron,—200 lbs. of flue dust which at 85 lbs. per cu. ft. is 2.35 cu. ft.

By weight this flue dust is but 27 thousandths of the total weight (7,700 lbs.) of all materials charged into the furnace, and by bulk but 23 thousandths.

From these figures it will be seen that the coke,—and not the iron ore and sintered flue dust,—is by far the bulkiest material entering the furnace, and is therefore the material most relied upon, by practical furnace men, to maintain the desired openness and porosity of the furnace burden.

As flue dust is identically the same material as most of the burden materials, which never get out of the furnace until reduced, there should be no objection to recharging flue dust as herein proposed, simply because it is of this nature.

There is a possibility of course, that some recharged dust will be again carried from the furnace, but there can be no objection to this taking place when the same dust is recovered again in the usual manner and inevitably returns, by either of the proposed recharging methods, into the blast furnace and sooner or later reaches such a depth in the mass of materials, from whence it cannot again be carried, and gradually descending to the reduction zone its metallic value is there finally realized.

Summarily the objects aimed at in this recovery system are the complete processing of operations of blast furnace gas washing and flue dust recovery that are either in present use or known to be practicable, and so arranging or coordinating these operations that it will be possible to accomplish practically a 100 per cent recovery of flue dust at each individual blast furnace; the location of the recovery plant near the blast furnace making possible the immediate recharging of the flue dust in de-hydrated sludge form, while its proximity to the blast furnace permits of a complete corrosive wash water disposal at the slag granulating pits; contamination of public water courses being thus avoided.

Steel Foundry Makes Sugar Mill Machinery

Very Interesting Discussion on This Class of Machinery and Engineering Work—Roll Design and Manufacture, Housing and Equipment Manufactured.

By JAMES J. ZIMMERMAN*

THE present design of sugar grinding mills is a culmination of development, caused by the necessity of their performing a certain work quickly, thoroughly and economically through a set and permanent principle. This principle begins at the rolls, whose duty is to squeeze, cut and crush the cane, in this way extracting the juice, as is shown by the diagram Fig. 5. Note the rolls are set so that there are two bottoms and one top, located respectively at the points of a triangle. These rolls rotate in the direction shown by the arrows on them, thereby carrying the cane in the path of the dotted line, marked "line of cane," thus crushing it and extracting the juice.

From this you may see that the rolls require means of holding them in position, hence shafts with journals and bearings, in which these can rotate, and housings with caps, screws and other equipment to maintain them in position while performing their work. Note that the quantity of cane must vary, and adjustment of the rolls must be cared for if the extraction is to be maintained at its maximum; hence the bottom rolls have a horizontal adjustment in and out. The top rolls ride on the bottom rolls when there is no cane in the mill, and when cane passes through they are forced up against the housing top caps, which are hydraulically equipped and which in turn, by means of pressure (125 to 250 tons on each cap), from the pumps and accumulators upon the rams within them, force the rolls downward with sufficient pressure to grip the cane, squeeze and crush it and extract the juice.

Mills are sized according to the number of stands and diameters and lengths of the rolls. For example, a nine roller 36x84-in. mill means three stands, each with three 36x84-in. rolls. The crushers are designated single and double or precrushing, and are sized according to the rolls, of which each stand contains two. Reading Iron Company manufactures all classes of mills and rolls of any size, from the smallest to those 36 in. in diameter by 84 in. long, with crushers in any arrangement and proportionate in size to the grinding mills. These rolls with shafts in them weigh up to as high as 18 tons. The same principle applies in the crushers, except that there are only two rolls to each stand, which work directly over each other, as shown in Fig. 6.

All moulds for grinding rolls are dry sand, and are formed by sweeping, in half flasks made of cast iron. (See Fig. 7.) After being swept out and faced, these half moulds are dried or baked (hence dry sand). A core which forms the rough bore of the rolls is formed in a core box and baked as is the mould. After baking, the mould is assembled and set up on its end and poured from the bottom, as illustrated in Fig. 8. After settling, they are removed from the moulds and cleaned and transferred to the machine shop for machining, a description of which will follow later.

Crusher rolls, types of which are shown in illustration, and which are either steel or air furnace iron, are cast in the same manner. They are not swept in the flasks, however, due to the contour of their faces, as will be described later, but are rammed up in the flasks from either solid or sectional patterns.

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*Assistant Superintendent, Scott Foundry, Reading Iron Company.

When the rolls come to the machine shop, they are placed in lathes where they are chucked on the one end and run on the dead center through an internal spider within the bore, and during this setting they are tested by running a cut over the surface to determine their quality and whether or not they are spongy. They are then swung into special steady rests on the same lathe and bored simultaneously from both ends to the required diameter by means of a special double headed boring bar which contains several cutting tools. They are then taken from the machine and await their being placed on the shafts.

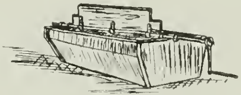


FIGURE No 7.

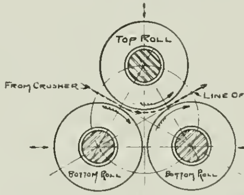


FIGURE No 5
GRINDING-ROLL DIAGRAM.

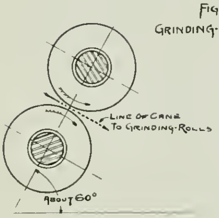


FIGURE No 6.
CRUSHER-ROLL DIAGRAM.

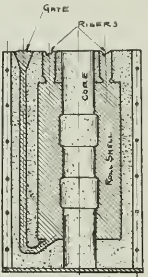
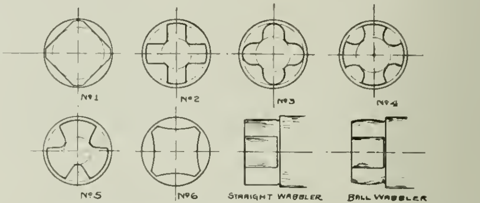


FIGURE No 8
METHOD OF POURING

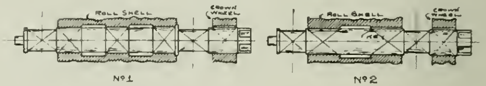
Note in the illustration (Roll Shafts) that the longer and larger rolls are either of the three bearing type, as No. 1, or the two bearing type, Fig. 2, so formed by coring in the foundry. The lengths of these bearing points vary with the diameter and lengths of the rolls from 24 to 30 inches.

The shafts of either steel or wrought iron forgings are turned and faced in a lathe to the required diameter and fit in the shells. Many methods of fitting the shells on the shafts have been developed and exploited by various firms, mostly as talking points for salesmen, and due to this cause this company has and will continue to fit up rolls as desired. Reading advocates and furnishes rolls with all their mills with the shells shrunk on the shafts, which is beyond argument a method so secure that the shells positively cannot come loose. Again, this method of shrinking the shell on the shaft absolutely prevents any of the juice from the cane from entering and remaining between the shaft, its key and the roll shell, as is possible when other methods of putting the shaft into the shell have been used. The collection of this juice in different crevices, such as noted, permits fermentation or souring and consequently contamination of the good juice. These shrunk-on shells are removable by proper reheating, while at the same time the shafts are forced out in a hydraulic jack or press. Probably the next best method is to force the shafts into the shells in a hydraulic press under a total pressure of 550 to 600 tons. In either case the shafts are one-eighth of an inch more or less smaller in diameter at the lead end, enabling them to come closer to their seats in the shells before being pushed or shrunk in same.

After the shells have been placed on the shafts, they are again swung in the lathes for turning and grooving.



WABBLERS.



ROLL SHAFTS

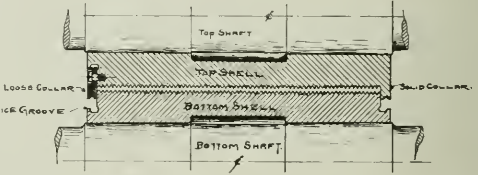
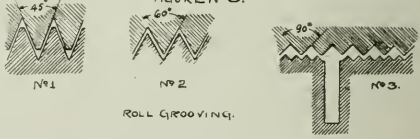


FIGURE No 9.



ROLL GROOVING.

These rolls, as shown in Fig. 9, contain grooves which run straight around the rolls and across their entire face, so that the grooves of the top roll fit into the grooves of the bottom roll, as especially illustrated under "Roll Grooving." The style of grooving varies with the views of the engineer, running from six to one groove for each inch of surface. They further vary in spread or shape from 45 to 60 and 90 degrees, as shown in full sized grooving cuts 1, 2 and 3, the latter being a patented form of grooving called "Messheart." In some instances where the size will permit, the grooves are chased with chasing tools, while all others are cut in one at a time.

As shown in Fig. 7, the top roll requires a collar which prevents the cane from squeezing out from between the rolls and into the bearings. These collars were formerly cast on the roll, as shown on the right, while on all recent installations they have been made separate from cast steel and are bolted to the rolls. Note that with this method the rolls become interchangeable, and should the wabbler on the top roll break off or become worn beyond use, it may be used as a bottom roll. Further, note the juice groove on each end of the bottom rolls, which catches the juice running over the roll and deposits it in the pans beneath rather than allowing it to go into the bearings.

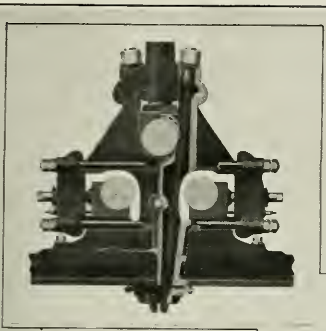


FIG. 10

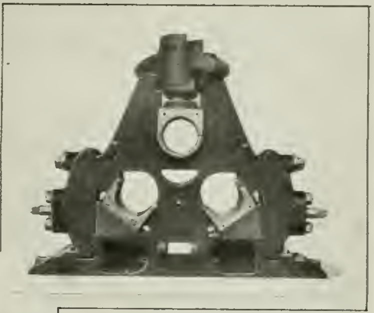


FIG. 11

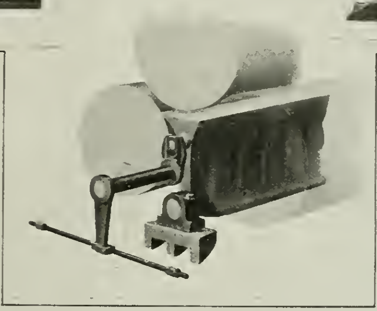


FIG. 12

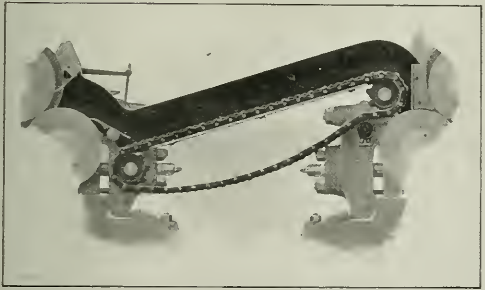


FIG. 13

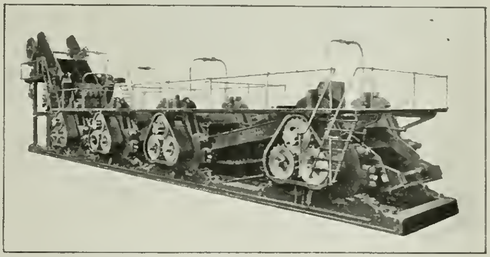


FIG. 18

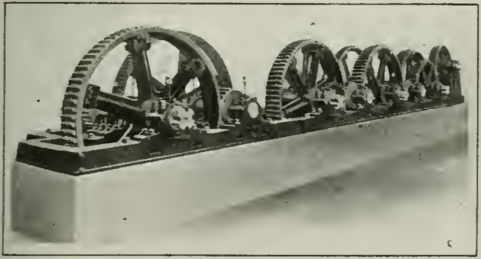


FIG. 19

FIG. 20

Next the top rolls are set up either on a planer or combination draw-shaper and boring machine, with the bearing journals resting on "V" blocks, where the wabblers are either bored or planed in the driving ends only. The projection on the other end is used for jacking up the roll to remove the bearings prior to removing the roll itself from the mill. Six types of driving wabblers are shown under the illustration (Wabblers), all of which will serve their purpose. Types 1 and 4 seem to be most used, with straight faces as shown by the side view (straight wabbler). The ball wabbler is seldom if ever used in sugar mill practice, and its principle is to form with the coupling box a ball and socket permitting, without difficulty, a greater lift of the top roll than possible with the straight type.

Housings and Equipment.

By referring to Figs. 10 and 11, you will see the two standard types of housings which have been adopted by the Reading Iron Company for heavy duty. The first type is generally known as the Rousselet housing, so named from the designer. This housing is either made of air furnace gun iron or acid open hearth steel, which is later annealed. Note that the hydraulic top caps, which receive the entire pressure of grinding, are held in position by king bolts (two for each cap), which pass on through the housing and are locked and held at the base by specially designed lock wedges. The side caps, which maintain the bottom rolls in position, are tied together and to the housing by tie rods (four to each housing). Use of other equipment may be seen, hence I take neither time nor space to tell of their functions. The second type, Fig. 11, shows the standard Reading housing, which is usually made from acid open hearth annealed steel. This housing differs very substantially from that of the Rousselet design, inasmuch as the top cap is maintained in position by a special bayonet lock, which locks or unlocks by a quarter-turn of the cap, thus permitting its quick removal. In this manner king bolts are eliminated. The tie rods, which hold the side caps in the former type housing, are also eliminated and are replaced by special tee-headed bolts at the top and wedge pieces at the bottom. Adjustment, or means of moving the bottom rolls, is affected differently for each type of housing, as will be noted.

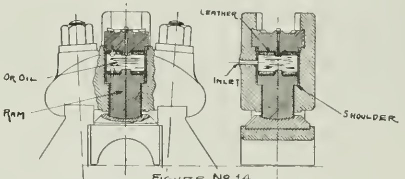


Figure No 14.
Housing Cap With King-Bolts

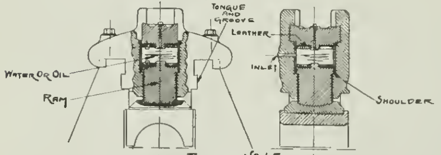


Figure No 15.
Housing Cap Without King-Bolt.

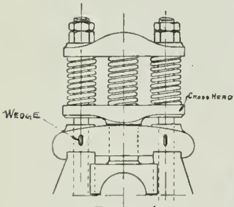


Figure No 16.
Housing Cap With Bolts & Springs

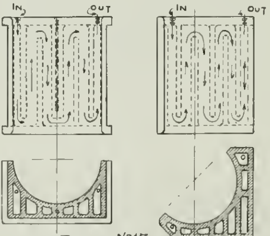


Figure No 17.
Standard Water Cooled Bearings.

Fig. 12 shows what is termed the turn plate, with its rest bar which serves as its support, and enables it to be adjusted through the bearings and adjusting rods at its base. The function of this turn plate is to turn or guide the cane through the two grinding passes formed by the top and two bottom rails. This turn plate is grooved with the same grooving as the bottom rolls, to permit its fitting down into the grooves of the roll itself, as can be seen in the cut, thus removing any cane which may adhere to the roll and turning it into the next pass for further grinding. These grooves are usually shaped into the plates, the pitch being regulated by a graduated plate on the screw of the shaper, which moves the table. For small grooves a tool with four to six grooves in it is used, while the wide pitched grooves are cut in separately. Sometimes, when the number of plates warrants the operation, the grooves in a number of plates are planed in one setting. In either method, strict attention is paid to the grooves fitting a template.

Fig. 13 illustrates what is termed the intermediate carriers, whose duty is to convey the partially ground cane from one mill to the next. These carriers, which span the distance between each mill and the next, are as wide as the rolls are long, and are constructed of specially formed metal slats which overlap each other, and are riveted at each side to two spans of steel roller chain, which in turn run over sprocket wheels which are driven through similar chain from sprockets on the bottom rolls. The side or guard plates, which maintain the crushed cane on the conveyor, are made from cast iron while the bottom plate, on which the conveyor slides, is made of fabricated steel plate with angles for stiffeners.

Figs. 14 and 15 show the hydraulic top caps for both type of housings, Fig. 14 with king bolts and Fig. 15 with bayonet lock. Note that the fluid, either oil or water, enters at the point marked inlet and forces the ram downward, due to pressure from the pumps and accumulators. These caps are made of open hearth steel and annealed. The tongue and groove which form the lock in the caps and housings without king bolts, are turned and bored in large vertical boring mills, large enough to permit the housings to stand up while being machined. The plugs in the caps are also held in position by a tongue and groove bayonet lock, and are removed, as are the caps, from the Reading type housing by a quarter turn, which throws the tongue from the groove and permits their being lifted out of position. Both the ram and the plug are made pressure tight by the leather packing cups which span their entire diameter and are held in place by steel plates or rims.

Fig. 16 shows an almost obsolete type of cap which is still in use on many mills, especially smaller mills. These caps are held down in position either by wedges, as shown, which pass through the cap and king bolts, or else by nuts on the bolts between the crosshead and the cap. These nuts are not shown. The crosshead is held down against the top cap by strong springs. It is in this manner that the top roll receives its downward pressure.

Fig. 17 shows the standard top and bottom roll water cooled bearings adopted by Reading Iron Company. These bearings are made from special phosphorus bronze metal having great wearing qualities and capable of resisting heavy surface loads with the minimum amount of frictional loss in power. The water course is formed by sand coring in the foundry. These cores which are dug out after casting require the highest type of workmanship on the part of the foundryman, for the slightest movement during the pouring may cause them to come loose from their anchors and float upwards, thus decreasing the thickness of the metal wall around them, which naturally causes, if not an opening when machining, a wall which soon wears away and allows the water to escape, causing the bearing to be thrown away.

Nothing particular need be said regarding the machining policies or practices in these parts, except that where possible the housings, bearings and caps or other parts are machined in groups, as on a planer. Otherwise standard machine shop practice is followed in all work. Much attention is paid to standardization of parts and these are laid out to templates and machined to standard gauges. This is also done to assist the plantation owner, by enabling him to carry only a few spares and yet be protected against breakdowns, and to permit and make sure of extra parts fitting correctly when ordered at a date later than when the mill was installed. The assemblage of the entire milling plant in the shops of the contractor before shipping is positively necessary in order to definitely insure perfect installation when it reaches its final destination.

Fig. 18 shows a standard 12-roller mill and crusher, with Reading housings, as it stood assembled in the Reading shops prior to its being shipped to Central Cambalache, Arcecibo, Porto Rico. This milling plant consisted of four stands of 34-in. and 84-in. rollers and a 30x84-in. "Krajewski" crusher. The first three mills were driven by a 34x60-in. "Corliss" engine and the fourth was driven separate by a 26x48-in. engine of the same type. The crusher was also driven independently by a separate "Corliss" engine 20x48 in.

Fig. 19 shows the gearing for this mill and crusher through which they were driven from the engines. Note that the rims of the gears are built up in sections and that they are shrouded and made from cast steel. These rims are fit together on solid spiders, which are made of air furnace iron, but which could be and often are made of cast steel. These spiders have a groove turned in them and the gear segments a tongue turned on the pedestals where they bolt to the spiders, in this way insuring proper alignment. The teeth in the segments are not cut, but they are faced on the sides and rims to insure balance and proper meshing into the pinions. This facing and boring on the pedestals is done on a large boring mill after the ends, where the segments join, have been planed and bolted together, thus forming the complete rim. They are then fit to the spider and the entire gear is centered from the teeth and the hub is bored out. The shafts are of either wrought iron or steel forgings, the manufacture of which has been explained, and are machined in a manner similar to that detailed for roll shafts. The bearings, which are separate from the bed plates, are planed and bored in groups. All bearings except those taking the engine shafts are lined wth babbitt, which is poured in them, well hammered or peaned, and bored out to size. Those for the engine shafts, which are of course the crank shafts of the engine themselves, which extend to the gearing bed plates and receive the first pinion which meshes into the first intermediate gear, are bored out and receive half brasses, which are machined all over and in pairs.

After the complete assemblage of the mill, gearing, crushers and engines in the contractor's shops, they are torn down and packed for shipment. Much care must be exercised in this packing, for it is practically all exported to foreign countries by ships. This means that the parts must be crated or boxed strong enough to prevent breaking, and in sizes small enough to permit handling. In many instances the final locations of the mills are far away from any railroad, and the machinery must be hauled in wagons. These wagons are pulled by oxen and have large wide-rimmed wheels which prevent their sinking into the mud during the wet seasons. The rolls are usually protected by lagging or strips, which cover the entire surface of the journals and grooving and are held together by steel bands.

Fig. 20 shows the above mill in course of construction at the Central, or grinding station, in Porto Rico. Note that the mill was assembled prior to the erection of the building, which carried a 10-ton crane. The absence of this crane necessitated the use of a jin-pole for all lifting during assembling. The engine for the first three mills can be seen at the right and in the distance the growing cane can be seen. Rigging can be seen for the erection of the structural iron for the building.

AMERICAN IRON AND STEEL INSTITUTE FALL MEETING

The twentieth general meeting of the American Iron and Steel Instiute will be held at the Hotel Commodore, New York City, on Friday, November 18, 1921. As usual a large attendance is anticipated.

Many interesting technical papers are to be presented, among which are the following:

"Welding," S. W. Miller, president American Welding Society.

"Steel Lumber," Thomas J. Foster, chairman National Bridge Works, Long Island City.

"The Relations of the Iron and Steel Industries to the Chemical Industries," J. M. Camp, director Bureau of Technical Instruction, Carnegie Steel Company, Pittsburgh, Pa.

"Direct Process for Steel Manufacture," A. E. Bourcoud, metallurgist, 200 Fifth Avenue, New York City.

"Refractories in the Steel Plant," W. A. Hull, Bureau of Standards, Washington, D. C.

"Improvements in Port Construction in Open Hearth Furnaces," J. W. Kagarise, Edgar Thomson Open Hearth Department, Carnegie Steel Company, Braddock, Pa.

HOOVER'S AID TALKS BEFORE ENGINEERS

Federal publication of daily surveys of business conditions, similar to the weather reports, was suggested by F. M. Feiker, special assistant to Secretary of Commerce Hoover, in an address before the Industrial Engineers Conference in Springfield, Mass.

Every business man in the country, Mr. Feiker declared, is waiting for some concise authoritative daily guide to the business situation, such as the forecasts of the weather now printed in the top right corner of practically all newspapers.

Mr. Feiker also discussed the subject of the elimination of waste in industry. He said that while this country had the highest ingenuity and efficiency in the operation of its individual industries of any nation, the American industrial machine is as yet far from perfect. In summarizing the principal factors contributing to industrial waste, he mentioned: (1) Lost labor during depression; (2) speculation and over-production in booms; (3) labor turn-over; (4) labor conflicts; (5) failure of transportation, fuel and power supplies; (6) loss due to processes and materials; (7) excessive seasonal operation; and (8) lack of standardization.

The Acid Bessemer Duplex Process

Review of This Interesting Process With Tests Taken During the Various Operations—Complete Operating Data.

By J. W. HAULMAN

A PLANT using the acid Bessemer converter as a preliminary refinery for blast furnace metal in connection with the Open Hearth furnace, which is known as the Duplex Process, has its advantages, whereby iron produced from certain ores can be utilized to better advantage by the removal of some of the impurities and thus relieve the Open Hearth furnace and shortening the time of the heat in the Open Hearth furnace by about 80 per cent.

There has been a number of these plants in operation using converters from 10 to 30 tons in capacity, and which enabled the producers to provide larger tonnages and expedite orders that could not have been produced by the Open Hearth Basic Process alone. In plants using this process it is usually arranged to have the blast furnaces supply the Bessemer converters with a suitable iron for blowing with sufficiently high silicon content to give a relatively higher temperature than is actually required and this temperature is then reduced and controlled by the addition of scrap into the nose of the converter in the earliest stages of the blow. The usual method is to completely desiliconize and blow the carbon down to about 10 per cent. This method of blowing commends itself on account of the regularity of the carbon content of the metal going into the Open Hearth furnace, and in most cases the more complete removal of other constituents.

Converter Lining.

The converters are lined with an acid lining most generally a silica rock. This silica rock showing an analysis of approximately,—SoO.—92 to 95 per cent; Al O—4 to 5 per cent, traces of Fe_2O_3 and MgO. The lining is started at the nose of the converter (the converter being set in a vertical position with the nose down) the nose ring is put in with stone cut to shape to form a complete circle and placed in a vertical position and are well keyed up, a Mica Schist stone serves the best purpose for this nose ring on account of it being softer and when the heat is poured into the converter there is less damage done by the iron ladle in ramming up against it, and there is less expansion in the Mica Schist than in sand stone or silica rock. From this point the stones are laid horizontally and the circular wall is then built up to within about a foot of the top when the shoulder is put in vertically and well keyed to serve as a binder for the entire wall when the converter is turned up to receive the bottom. This wall is usually from 15 to 18 inches in thickness and the stones are laid in a mortar usually made from the spalls or refuse left from the same stone in dressing, ground in a grinding pan and with the addition of a proportion of a good plastic clay, thoroughly mixed and ground fine so as to make good joints in the masonry.

The Blow.

The blow eliminates the silicon and manganese as oxides and then burns the carbon off as a dioxide and monoxide, phosphorus and sulphur are not considered as neither are affected by this process, it is with these elements, particularly phosphorus, that the open hearth furnace plays its important part. In the blowing of a heat it is essential to have the proper working temperature and it is for this reason that it is always best to have a blast furnace iron containing a higher heat producing element—namely silicon—than is actually required (not excessive as the nearer it is to the required blowing temperature the less scrap will be consumed) in order that the temperature can be better controlled by the addition of scrap. Manganese is also considered as a heat producing element to a certain extent but is very undesirable, as an iron running over 75 per cent manganese will cause a too violent reaction and cause "slopping" which will entail a high converter loss as well as it will have a corrosive action upon the lining of the converter and will result in a rapid destruction of the lining. The reactions taking place in the converter at different stages of the blow are noticeably of three different parts, namely—the slag forming stage, the boil, and the finishing stage, and may be more clearly shown by the following blowing test showing the elimination of carbon and silicon during each two minute period of the blow.

	Chemical Analysis of blown Metal.		Per cent oxidized at the end of each period.	
	C.	Si.	C.	Si.
Iron into the converter..	4.30	1.00		
After blowing 2 minutes	4.280	.75	.020	.25
After blowing 4 minutes	3.928	.40	.352	.35
After blowing 6 minutes	3.548	.15	.380	.25
After blowing 8 minutes	3.147	.06	.401	.09
After blowing 10 minutes	2.379	Trace	.768	.06
After blowing 12 minutes	1.599	Nil	.780	.00
After blowing 14 minutes	.843	Nil	.756	.00
After blowing 16 minutes	.213	Nil	.630	.00
After blowing 18 minutes	.078	Nil	.135	.00

This heat blew 18 minutes which is unusually long and which was undoubtedly due to the converter being turned down every two minutes to get the test. The oxidation would have been considerably faster on continuous blowing as each time the converter was turned down the blast was necessarily shut off.

During the slag forming stage, iron oxide is formed and the greater portion of the silicon and manganese are oxidized and unite with the iron oxide to form a double silicate of iron and manganese slag. Under normal conditions with a proper temperature, the carbon is not appreciably attacked until a considerable portion of the silicon has been oxidized, and what carbon has been removed up to this point are such amounts that are oxidized and pass off in the form of carbon dioxide (CO_2) and is noticeable by an irregular violet colored flame from the nose of the converter. This flame gradually becomes steadier as the temperature increases until it reaches a yellowish color, at this point the carbon begins to oxidize more rapidly as the boil commences and during the continued oxidation of silicon and manganese the greater portion of the carbon is also removed mostly in the form of carbon monoxide (CO) and the portion of the carbon dioxide (CO_2) rapidly decreases. It is this formation and escaping of this gas that causes the boil and is noticeable by the heavy yellowish flame from the nose of the converter, and the temperature is greatly increased and with this violent boil very often quantities of iron and slag are ejected from the nose of the converter. During the finishing period a small amount of silicon and the remainder of the carbon is oxidized, the carbon to monoxide (CO) as the temperature is too high to produce dioxide (CO_2). The action gradually becomes less and the flame begins to drop which shows an almost complete removal of the carbon. The flame drops very rapidly which signifies that the blow is completed and the vessel is then turned down, the blast being shut off as the converter begins to turn and the metal gets away from the bottom so as to keep the tuyeres in the bottom open. It is then poured into a transfer ladle and delivered to the Open Hearth furnace. In making up the charge for the Open Hearth furnace, two or three converters may be blown at the same time and poured into one ladle and it may be necessary to repeat the cycle of operation several times in order to give the required amount for the Open Hearth, depending entirely upon the capacity of the furnace receiving the charge which may be up to the 200-250 ton capacity type.

In this connection it might be well to add that to get iron of a uniform composition it is essential to have a metal mixer of considerable capacity in close proximity with the converters, so that a good mixture of iron produced from several blast furnaces furnishing iron of variable analysis. However, the specifications of iron for the Duplex process may be considerable broader than would be required for the straight Bessemer practice, yet it is desirable to have an iron with some uniformity. It is also beneficial to keep as much of the slag and kish from the blast furnace ladles from entering the mixer as possible as this not only tends to give trouble in the mixer but if any be allowed to enter the converters it will materially lengthen the blow, cause serious "slopping" of the heat with the attendent loss of product and hinder chemical reactions.

The blow with the resulting reactions as described above is particularly applicable to the 15 to 18-ton concentric type converter. Larger converters of the 25 to 30-ton single belly type do not always blow a charge in this way and very often show a greater variation in temperature especially in the later part of the blow, very often more carbon is burned to dioxide (CO_2) during the later part instead of monoxide (CO). In many instances the blow may not be initially too high in silicon and yet finishes at an exceedingly high temperature. This practice does not commend itself as the chances for reduction in temperature at this point of the blow is exceeding small, being impossible to get sufficient scrap into the blow at this stage to have any material effect upon it, the only resort is to turn steam into the blast and thus endeavor to reduce the temperature somewhat. The best practice being to lower the temperature by burning the carbon to monoxide (CO) which will also have a vast saving effect upon the converter bottom, as this excessive temperature at the later part of the blow will have a tendency to allow the metal to come in closer contact with the converter bottom and thereby shorten the life of it. It is for this reason that the varying temperatures encountered in the large type converter has such a varying effect upon the life of the converter bottom and greatly increasing bottom expense.

It is a well known fact not all reactions take place in the same order or at the same time in different blows, as at one time or another some one reaction may be taking place more rapidly.

The oxidation of manganese carbide may result at a lower temperature and produce manganese oxide and carbon dioxide and the oxide of manganese along with the magnetic oxide of iron will form with the silica previously produced. On the other hand the temperature of the mixer metal may be higher and contain more silicon with the result that after the silicon has been oxidized on account of the high temperature, the silicide of manganese will then burn and the manganese carbide remain in the bath. This manganese carbide then acts as a very active reducing element and begins to reduce the silicon in the silica to metallic silicon and also reduces the magnetic oxide of iron to ferrous oxide, the result being an excessive converter loss.

In the small converter it is unusual for the carbon to be eliminated before the silicon, but in the larger converter this may be possible due to the exceedingly rapid rise in temperature and the carbon may be oxidized before the silicon is eliminated.

Depth of Metal in the Bath.

If the depth of metal in the converter be too shallow more oxygen of the air blown will escape unburnt than should do so. This unusual excess carries off heat passing off at the vessel temperature, which cools the vessel and also the charge. The proper depth of metal should range from 18 to 22 inches, and should bear the proper relation to the number and size of the tuyere holes in the bottom. These holes admitting the blast should not be larger than will allow the oxygen in the blast to be as completely consumed as possible. ½" or 9/16" holes have proven a good standard in converters ranging from 15 to 25 tons, varying the number of tuyeres with the weight of the charge to be blown, assuming 6 to 7 cubic feet of air per pound of charge. There has been a tendency to raise the blast pressure too high, in large converters, resulting in the air burning the carbon to carbon dioxide with the excessive amount of air, instead of burning it to carbon monoxide with about half the air, and then burning the carbon monoxide at the nose of the converter with the oxygen from the atmosphere, which will result at times in abnormally high temperatures in large converters and thus require an excessive amount of scrap which is the prime object of large converters to reduce to a minimum.

Control of Temperature.

If too high a temperature is observed from indications during the first stages of the blow when the silicon begins to oxidize, it is the usual practice to get sufficient scrap into the converter to bring the temperature down as quickly as possible. The indication of the temperature can be readily seen in the first two or three minutes of the blow by smoke appearing at the nose of the converter, the earlier this appears and the larger the volume the hotter the charge. If in scrapping, not sufficient scrap has been added to the initial blow to bring the temperature within proper bounds it is usually arranged to have a steam connection into the blast line entering the converter and as a last resort, the steam is blown in with the blast, this has a cooling effect, but does not commend itself on account of the formation of more oxide of iron and tends to greater loss.

If the temperature is on the cold side the charge may be warmed up by blowing on the side, the vessel is tipped part way over, bringing some of the tuyere holes above the metal and the blast from some of the others blows through the shallow part of the bath, causing an excess of oxygen above the bath which burns some of the carbon monoxide (CO) to CO_2 and will also burn some of the iron to oxide. If necessary this may be continued for nearly the full length of the blow and may be done by tipping the vessel from side to side. The loss, however, will be considerably greater than with a normal blow.

The length of time elapsing between blows adds materially in reducing temperature in as much as the converter, especially if it has a large nose, will cool very rapidly and can be materially affected by climatic conditions, in which in a very short interval the converter has become black.

Size of Converters.

During the last few years it has been the tendency towards large converters. From an economical standpoint this remains yet to be proven if the 25 to 30-ton converter can be as satisfactorily operated and as economically maintained as the 15 to 18-ton type. It also remains to be proven if as much tonnage can be produced through this large sized converter as has been produced in the "old Bessemer days" with the small converters, as also the quality of the steel produced. Being experienced in the operation of both types, the advantageous and economical part of the large single belly converter has not clearly manifested itself to me. I know from the use of a certain kind of iron which had an extremely corrosive effect upon the linings of both, the upkeep of the large sized converters was very much in excess in cost per ton of steel produced than was the upkeep of the smaller type. The converter bottoms would stand as many blows yet the amount of refractory material required to put up such bottoms was double the amount required for smaller converter bottoms, the same being true with the stone lining of the converter, yet the tonnage produced per blow was only about 1/3 more. While the length of blow may be practically the same in both cases, the speed of operation in charging the converters and taking the heats away from it is considerably slower due to the fact that the increased weight of heats require heavier and slower traveling cranes and therefore retards the speed of operation to such an extent that the additional tonnage per blow would not be on a balance with the tonnage produced in a smaller converter with light and more active crane facilities.

Converter Bottoms.

The bottoms are put up by inserting tuyeres up through a cast iron plate and a mixture of gannister, consisting of a gannister rock or clay brick bats mixed with fire clay and loam with a moisture of about 10 to 12 per cent, is securely rammed around the tuyeres, layer by layer until the entire bottom is filled up. They are then placed in an oven and baked at least 72 hours with a slow oven temperature ranging about 600 degrees F., and should be put on the converter as soon after coming out of the oven as possible. Great care should be exercised in the putting up of bottoms as to the grade of material used, an inferior material in the gannister will cause the gannister to eat away from the tuyeres causing short life. The holes in the tuyeres must be governed by the size of the converter and should be of such diameter as to allow the oxygen in the blast to be as completely consumed as possible which will materially aid in controlling the temperature.

Slag.

The slag volume with certain kinds of iron will run as high as 12 to 15 per cent on certain heats and has averaged 10 per cent for indefinite periods. High temperature developed by the silicon will produce a very fluid slag of silicate of manganese which will have a very corrosive effect upon the linings. The Bessemer charge is poured into the Open Hearth furnace through a nozzle and runner on the side of the ladle and when the slag appears at the nozzle, the ladle is quickly tipped back and none of the acid Bessemer slag is allowed to enter the Open Hearth furnace, the ladle is then carried back and the slag is dumped into slag bowls.

Losses.

The loss in the duplex process is greater than the straight Open Hearth Basic process, which is due to the elimination of carbon, silicon, etc., in the converter, whereas the scrap in the ordinary Open Hearth process has already withstood such a loss in its original conversion. To satisfy the slag in the Bessemer conversion about 2 per cent of metallic iron is oxidized in the converter; this together with a small loss in shot and spittings are the only losses sustained in the duplexing process not common to both processes working with the same materials .

PITTSBURGH FOUNDRYMEN'S ASSOCIATION

A. E. Blake, Pittsburgh manager of the United Gas Improvement Company, Philadelphia, who was the speaker at the regular monthly meeting of the Pittsburgh Foundrymen's Association at the General Forbes Hotel, October 17, could see no good in the present day gas producers, which he declared were relatively as wasteful of coal and heat as the beehive ovens were of coal and useful by-products, while admitting that the coal reserves of the country were ample for centuries to come, it was not too soon to begin to think of the conservation, he declared, and strongly urged the use of other means of gasification than the producer. He asserted that producer gas contained so much nitrogen as to decrease very materially its efficiency and also pointed out that since it could not be sent great distances the furnaces had to be nested close to the producers. The gas must be low in sulphur, he insisted, to avoid the spoiling of heats, claiming that on an average one per cent of open hearth heats were being spoiled by the use of poor producer gas. Coal and water gas installations were advocated by the speaker.

By-Product Coke Plant Regulation

Gas Regulation System of the Northampton Works of the Bethlehem Steel Company at South Bethlehem, Pa.—Operating Datum Show Superiority of System of Control from Battery Regulators.

By W. M. SHALLCROSS
Northwestern Manufacturing Company

THE Northampton Works at South Bethlehem is now the largest coke plant where the gas is handled under the new method, which neglects the suction at the coolers and operates the exhausters entirely from the indivdual regulators on the batteries. The operation of the plant demonstrates the soundness of the principle both in theory and practice, when applied to large plants as well as to small.

Under the former system, the suction was maintained as uniformly as possible at some point in the gas main, usually at the cooler inlet, and the oven regulators were then required to do the fine work of regulating at each battery. This scheme had two long-standing and much discussed defects. First, it was necessary to maintain, either manually or automatically, a cooler suction high enough to give the most distant battery regulator a safe operating margin at all times. This meant that the cooler suction had to be changed from time to time as plant conditions changed and as the oven operators sent in reports asking for more, or less, suction.

The second and most serious defect of this scheme was the tendency of the automatic suction regulators on the exhauster engines to "hunt" with the battery regulators. When two regulators attempt to maintain a uniform suction or pressure in the same gas main, even at two widely separated points, there is always a theoretical possibility of the two regulators setting up a swinging "see-saw" between themselves—one regulator opening while the other is closing—back and forth in regular periods. In about 90 per cent of the plants under the writer's observation, this theoretical possibility had become a practical fact, the regulators in the entire plant running almost continuously from limit to limit, the periods of each complete swing ranging from 60 to 110 seconds. Although this hunting can be temporarily stopped, it is apt to start at any time and will often continue for a long period.

The objections to this hunting are several:

(1) The battery regulation is poor.

(2) The regulators and engine valve parts are worn by constantly operating.

(3) The steam consumption of the exhauster engines is high, due to the engines continually changing from high to low speed and vice versa. The fact that the engines have to be operated at a speed high enough to give a liberally high suction at the most distant battery also tends to lower the steam economy.

Description of System.

At the time of observation, the Northampton plant was equipped with a Northwestern complete electric system of regulation. There were three batteries in run, each battery consisting of 106 ovens with four regulators, each regulator handling gas from 26 to 27 ovens. At that time five ovens were pushed and charged under each regulator every six hours, so that during the 25 or 30 minutes while these five ovens were being charged, the regulator opened wide, then gradually closed for six hours, until the next group of five were charged. (The gas flow was very erratic.) The shortest run of gas main to the exhauster house was 410 feet and the longest was 925.

In the exhauster house there were five 150 cu. ft. exhausters driven by two Buckeye and three Stumpf Unaflow engines. It was necessary to run only two at a time to handle the gas. The exhausters drew from and discharged into common headers. The speed of the exhausters was regulated by a Northwestern controller located at each engine. The Buckeyes were controlled by shifting the steam cut-off valve and the Unaflows by varying the amount of inlet valve opening at each stroke.

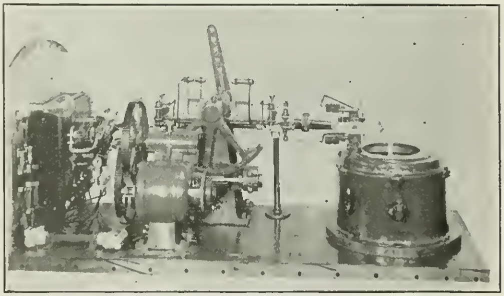


Fig. 1—Regulator with housing removed.

Each engine controller consists of a motor with gears and necessary limit switches enclosed and mounted on a floor pedestal. A shaft extends from the rear of the housing, which is connected to the valve gear of the engine. On the front of the pedestal is the control lever, by which the controller may be operated by hand—the engine speed being either raised or lowered or the system put in the "automatic control." By putting the lever in the "dead" position, the motor, with all its connections, is disconnected. Signal lights are mounted on each controller to indicate when and how the controller is operating.

All controllers are connected to a centrally located switch panel which contains the magnetic switches, relays, knife switches for hand control, signal lights and fuses. This panel is installed in a small room in which will be the gauges and recorders, making it a central point for the gas handling system. This small control room will be free from any explosive mixture of gases which might accumulate in the exhauster room. All contacts in the engine controllers, which might arc, are placed in gas-tight enclosures to avoid all possibility of explosion.

The regulating system was arranged to operate in either of two ways:

(1) From hontoon switches with pressure line tapped into the cooler inlet, or

(2) From the battery regulators.

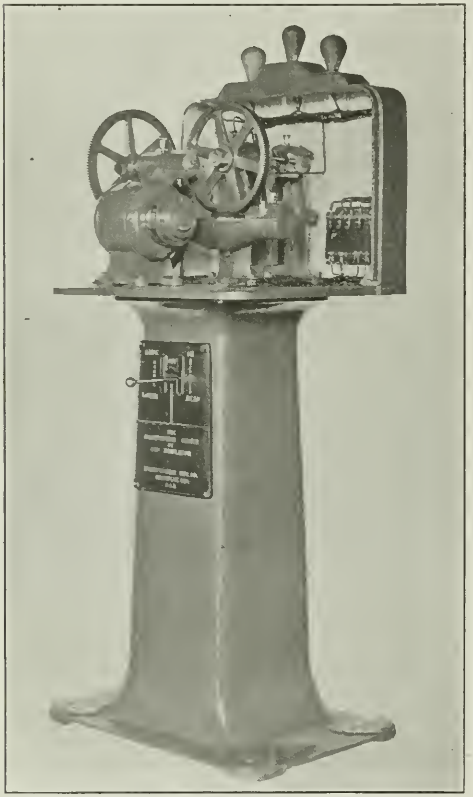


Fig. 2—Engine controller with enclosing cover off.

The hontoon switches, arranged for a maximum suction of 20 inches of water, were also installed in the small motor control room with the control panel and gauges. For operating the system from the battery regulators, each Northwestern butterfly valve regulator was provided with an adjustable contact maker by means of which an impulse was sent to the central control board whenever the butterfly valve had reached a predetermined position, both in the opening and in the closing directions.

The control switch on each butterfly regulator is adjusted so that the circuits to the exhauster control panel are closed when the butterfly valve is about 10 degrees from each end of its travel. This allows the valve to travel 60 degrees in the clear without operating the engine controllers. There are four regulators to a battery, making a total of 12 regulators. Two batteries feed into one main and one set of coolers, while the third battery is on a second main with its coolers. All exhausters draw, however, from a common header.

The battery regulators are connected to the exhauster engine control panel in such a way that whenever any butterfly valve reaches a position of 80 degrees open, an impulse is sent to the exhauster controllers and all the engines are slowly speeded up. This speeding up continues as long as the butterfly valve is within its last 10 degrees of travel, but *only* while the butterfly valve is still opening. While the butterfly valve is stationary or while it is closing, towards its 45 degree position, it does not operate the engine controllers. This feature is to prevent hunting. In a similar manner, when any butterfly valve gets to within 10 degrees of being closed it slows down the exhauster controllers.

The broad principle is that when a butterfly regulator is working within a zone about 35 degrees each side of the midway or 45 degree position, it is entirely able to give good regulation alone, but if it gets within about 10 degrees of either end of its travel, it must call in outside help and this outside help consists of the controllers on the exhauster engines. There is no need whatever of the exhauster engines trying to do any of the regulating as long as the butterfly regulators are in good workable positions.

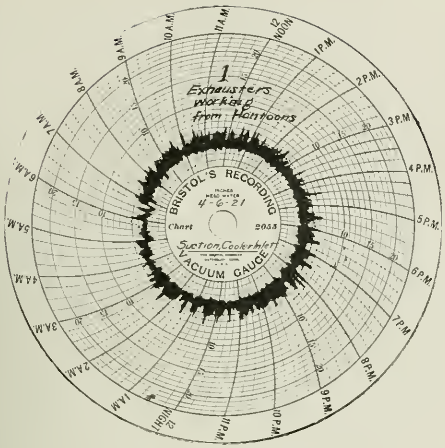
Operation on Hontoons.

The plant was operated by both the old and new method, in order to get comparative data. The hontoon switch was set to hold four inches of suction at the cooler inlet, the switch being especially designed to be perfectly dead beat to avoid, as far as possible, overtravel and hunting. The switch contacts were set so that a change of about .05 of an inch water pressure was sufficient to operate the controllers. Under these adjustments the mean suction held at the cooler inlet was four inches. The controller hunted almost continuously and it was impossible to make adjustments that would entirely prevent all hunting. The chart No. 1 shows that between 5 A. M. and 6 A. M., when there were no ovens pushed, there was no hunting and that between 3 A. M. and 5 A. M. there was very little. The controllers hunted practically all the rest of the 24 hours.

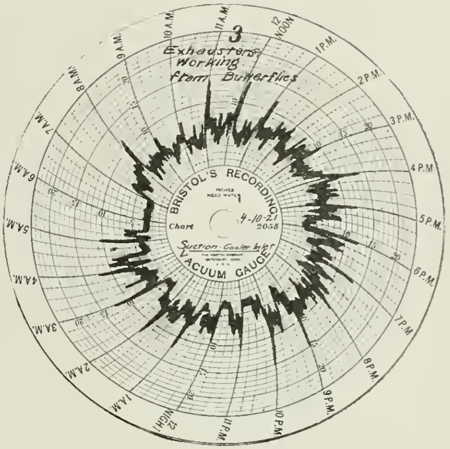
This hunting consisted of regular swings of the engine speed from high to low and vice versa. The controllers ran continuously in one direction for about 50 seconds, rested for five, and then ran back, making the complete cycle in 110 seconds. Meanwhile, the battery regulators were opening and closing also in regular periods of 110 seconds, the battery regulators opening while the exhauster engines were slowing down and vice versa. The battery regulators were on the average running 25 seconds out of every 60, 42 per cent of the time, and the engine controllers operated 50 seconds out of 60, 83 per cent of the time. Even with this almost continuous hunting, the regulation on the batteries was satisfactory, as shown on chart No. 2, which was an average one. The maximum variation was scarcely 1½ mm. of water pressure with an average variation of about 1 mm.

Operation on Battery Regulators.

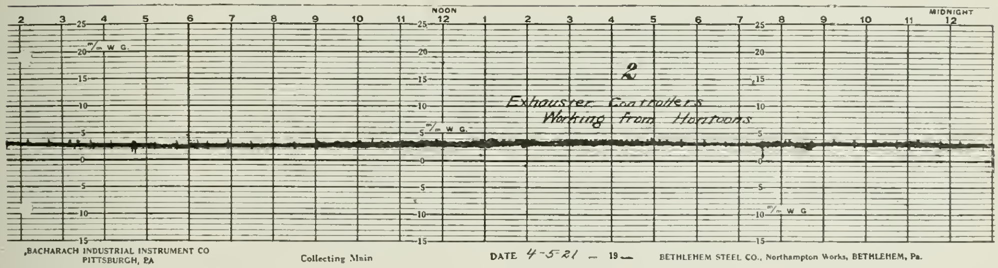
The system was made to operate from the battery regulators by throwing over a knife switch on the control board, which changed it from the hontoon control to the butterfly control. The first effect noticeable was that immediately the regulators quieted down and all hunting ceased. Repeated efforts were made to start this hunting again, but they all failed. The next effect observed was that the suction at the cooler inlet became



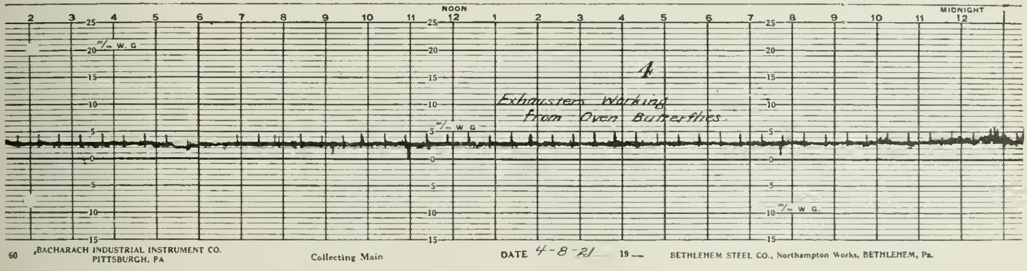
No. 1 Suction at Cooler Inlet with Bontoon Control



No. 3 Suction at Cooler Inlet with Butterfly Regulator Control



No. 2 Pressure at Ovens when operating with Bontoon Control



No. 4 Pressure at Ovens when operating with Butterfly Regulator Control

variable, as shown on Chart No. 3. This variation was to be expected, since there is no attempt made now to hold this suction constant.

The battery regulators and the engine controllers were much quieter under this system. The battery regulators averaged 12 seconds of operation out of every 60, or 20 per cent, as compared with 42 per cent before. The engine controllers operated three seconds out of every 60, or 5 per cent, as compared with 83 per cent when the system was operating from the hontoons This great reduction of operating time of the regulating equipment—52 per cent for the battery regulators and 94 per cent for the engine controllers—was due almost entirely to the absence of hunting, and the wear and tear on the regulators will be reduced by the same amount.

Observation of the main control panel during operation was extremely interesting. Three signal lights are mounted on the panel—a green light shows that the controllers are raising the engine speeds, i. e., the suction is too low for the battery regulators, and a blue light indicates too high a suction and that the engine speeds are being reduced. The third light, a red one, burns whenever two battery regulators reach opposite ends of their travel and one tries to raise the exhauster speed while the other tries to lower it. The engine controllers do not operate in either direction while the red light is burning.

At the Northampton works, because of each battery regulator getting a fresh charge of gas from five ovens only, at six-hour intervals, the red signal light flashed occasionally. At such times the two battery regulators in the extreme positions could at once be located by control board and noting which two extinguished the red light. Furthermore, the switch which lit the green lamp, as it extinguished the red, indicated the battery regulator which was too far shut, and in the same way the switch that extinguished the red and lit the blue lamps was connected to the battery in which the regulator was too far open. All the red lamp indications during the observation were mere momentary flashes, but if they had persisted the battery in trouble, as determined by the above tests, could have been at once investigated for tar stoppages, loose butterfly valve, or other trouble.

The battery regulation is slightly improved, although the regulation under the first plan of operation was very good. Chart No. 4 is a typical battery chart, the variation throughout averaging considerably less than 1 mm. When it is remembered that this 1 mm. is only one nine-thousandth of an atmosphere, the regulation is remarkably close. The rises in the pressure at regular half hourly intervals, as shown on the charts, are caused by reversale in the generators.

Steam Economy.

The most remarkable improvement in operation was the decrease in steam consumption of the exhauster engines. This increased economy seems considerable. A careful series of tests are now being carried out to complete data on the subject.

This steam economy when operating the engine controllers from the battery regulators seems to be largely due to the absence of hunting. The writer believes that if careful tests were made on steam consumption of an exhauster engine, both while hunting and while running uniformly, it would be found that the non-hunting engine pumped the same gas with far less steam. An engine which is continually speeding up and slowing down is necessarily a wasteful machine

In the past, high steam economy in the exhauster house has never been held up as a much desired goal because steam was cheap in a coke plant and the by-product plant was always, and still is, a good market for low pressure exhaust steam. However, now that waste heat boilers are being replaced by regenerators and all fuel is becoming expensive (even coke breeze is coming to have a price on it), more and more attention must be given to steam economy and the new apparatus or new method of operation which saves steam will be the one which will receive the best attention.

Conclusions.

In general, it can be said that the operation of the plant, on the two systems of control, for the purpose of getting comparative data, showed an enormous superiority for the system of control from the battery regulators, over that of maintaining the suction constant at the cooler inlet. The points of advantage may be listed in the order of their importance, thus:

First—A very material steam saving.

Second—Less wear and tear on the regulating equipment.

Third—Improved battery regulation.

Fourth—Less attention because of the non-fixed suction. But first and foremost stands the steam economy which overshadows all the rest and which alone would justify the newer system.

STUDY OF DEPRECIATION AS IT RELATES TO PRODUCTION

Of unusual interest to the implement industry is a study of depreciation as it relates to production just made by the Fabricated Production Department of the Chamber of Commerce of the United States.

The results of the investigation are given in a pamphlet issued by the department. This pamphlet offers suggestions to ease the burden of depreciation in this period of business recovery; notes the importance of obsolescence; discusses the relation of depreciation to fire insurance; includes and explains a useful form of property ledger; points to the great need of establishing standard or guide rates of depreciation in all commodity lines; and emphasizes the great importance of including depreciation in every day current costs.

"Each twist of the handle and blow of the hammer help to wear out plant and equipment, and the particular job or process that causes this loss should bear the cost," according to the pamphlet. "The basis of lower prices must be a greater efficiency and complete costs. To that end everything turned out by the factory should bear a proportional cost of depreciation."

The advisability of adjusting depreciation to production is carefully developed in the pamphlet. It is set forth that "during war-time, production equipment was operated at a pressure far above normal, entailing extraordinary wear and tear, to compensate which an extra allowance for depreciation was recognized as necessary. If this was so, if excess operation meant excess depreciation, is not the converse true? Does not light operation warrant scaling of depreciation? Are manufacturers not justified in minimizing their losses by adjusting depreciation charges to the flow of depreciation?"

Attention is directed to the need of giving the factor of obsolescence the consideration and allowance it ordinarily deserves when determining the useful life and rate of depreciation of machinery and equipment. On this point, the pamphlet avers that "property is most generally replaced before it wears out by something bigger and better. Give the American business man a machine that will render better and cheaper service, and he will scrap his present equipment, even though the paint has not worn off."

The pamphlet makes a plea for business men to abandon rule-of-thumb rates of depreciation, to study their own depreciation situation, and check their experience with that of their trade group.

"The best judgment regarding depreciation would be only an approximation frequently belied by subsequent experience, but there is a difference between gussing and stimating. A guess cannot be justified. It is a hit or miss affair. An estimate of depreciation attempts to take in all the factors governing a given situation, to assign weights and importance to them, to rely upon past experience and actual inspection of property, to differentiate between the various kinds of machinery, building, etc., and to apply depreciation with reference to a particular asset or a group of assets."

For the proper recording of depreciation, the pamphlet provides a useful and simple form of property ledger.

New Heat Treating Plant for Motor Parts

Describing the Plant Where Parts for the Nash Four Are Carbonized, Hardened and Drawn—Orderly Arrangement of Furnaces, Quenching Tanks, Etc., in Modern Building Is Noted.

By CLINTON A. ARMSTRONG, Chemical Engineer,
Chicago Flexible Shaft Company

THE Nash Motors Company of Kenosha, Wis., builders of the Nash Six motor car, entered the market with a Nash Four at the Chicago Automobile Show in 1921, a car which is a replica of the larger car in many respects.

For the building of this car the Nash Company erected a plant in Milwaukee, Wis., near the southern city limits, on a plot of ground which will give them ample room to enlarge the plant as the demand calls for it. At present the plant is equipped for and producing about 50 cars per day.

The equipment and layout of the plant are in agreement with the most approved practices of today, and the heat treating department, that part of the plant in which we as a class are most interested, is no exception.

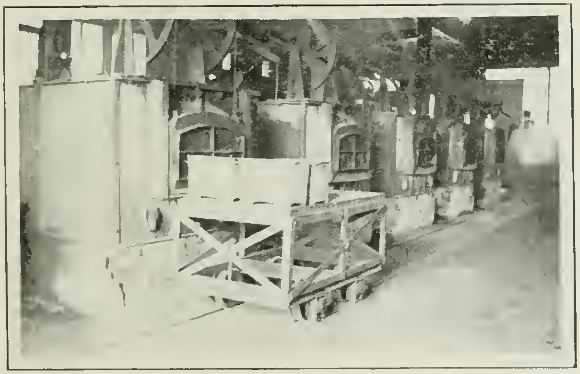


Fig. 5—Stewart carbonizing ovens with industrial railway car in the foreground. This car makes the matter of loading and unloading the heated boxes a simple proposition.

The heat treating department is housed in a separate building just east of the main plant, designed especially for the purpose. The building, 80 feet square, of steel frame construction, has a 30-foot central corridor 25 feet high, with 25-foot bays on either side 16 feet high. The walls are of hollow tile for the first 5 feet, surmounted by 10 feet of steel sash with frosted glass panes running around the entire four walls of the building, thus making the shop light and cheerful. The roof is of concrete tile, a type of construction which is cool in summer and warm in winter. The central bay is 10 feet higher than either side bay, and advantage is taken of this to insert more steel sash with swinging sections for ventilation.

The large 20-foot doors placed in the center of each end aid in ventilation during the summer and help reduce conveying problems.

The layout of the plant, Fig. 1, is simple, yet efficient.

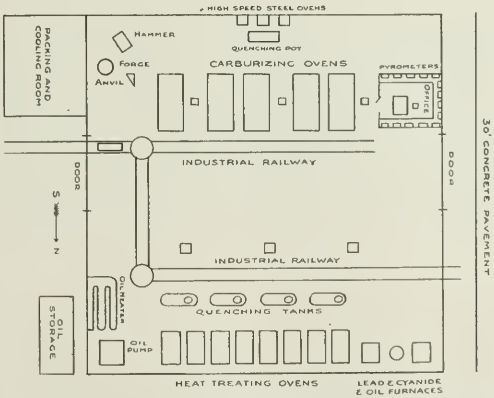


Fig. 1—Sketch showing the layout of the heat treating department of the Nash Motors Company at Milwaukee, Wis.

The five Stewart carburizing ovens, it will be observed, are located just to the right of the center of the room and are served by a small industrial railway car, the tracks of which are directly in front of the ovens. On this track cars are operated which have platforms of fire brick at the same height as the furnace hearths (see Fig. 5), thus making the transferring of loaded or heated boxes to or from the furnaces a very simple proposition.

Another very good practice made possible by the use of the transfer car is the packing and cooling of all boxes in a special room just east of the main building. This practice is conducive to cleanliness in the main room and leaves the main corridor clear for trucking.

Eight Stewart semi-muffle heat treating furnaces, 15 in. high by 24 in. wide by 36 in deep in size, occupy almost the entire length of the north wall of the room. These furnaces are extra heavily insulated, thus making the maintenance of an even temperature easier. These furnaces are also served by an industrial railway located just south of the quenching tanks, a feature we will discuss later.

The cyanide, lead and oil tempering furnaces are grouped in the northwest corner of the building, near the door, and are served by a quenching tank identical with the rest of the tanks.

Directly in front of the heat treating furnaces are located the concrete quenching tanks, each serving two furnaces. These tanks are noteworthy as they are of concrete, 7 feet long, 3 feet wide and 8 feet deep, elliptical in shape, with two feet above the surface of the floor. In one end of the tank a 24-in. cylindrical oil quenching tank is suspended, thus making use of the circulating quenching water for partially cooling the oil.

The quenching oil is further cooled, however, by circulating it by means of a 200 gal. per minute Deming rotary pump through a double tube radiator at the east end of the door, through the center of which the circulating oil flows. This practice keeps the quenching oil at a low temperature, and serves to partially heat the fuel oil at the same time.

The heat from the circulating quenching oil, however, is not sufficient for extreme winter weather, and at such time steam is turned into a heating coil located in the bottom of the 25,000 gal storage tank buried just outside.

Fuel oil is supplied to the furnaces at 50 lbs. pressure by means of a direct motor driven Deming 150 gal. rotary pump, and in accordance with the most approved practice the oil system is of the full flow return type.

All fuel oil, quenching oil and water pipe lines are placed in covered trenches located at the rear of the furnaces and between the rails of the industrial railway running alongside the quenching tanks, thus making them readily accessible in any emergency, and at the same time entirely out of the way.

The industrial railway has been found to be of inestimable value for the handling of the work. The tracks run along the front of the carburizing ovens, with turn-tables at either end and cross tracks interconnecting the two, thus making the transfer of work to and from the ovens an easy matter. The cars are ball bearing and operate with very little effort.

Air for the furnaces is supplied by individual, direct connected motor driven blowers at 14 oz. pressure.

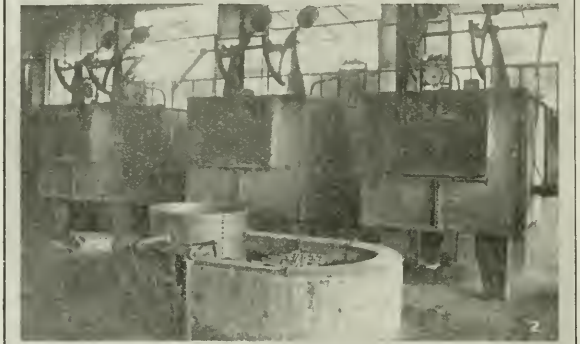
Not the least interesting of the Nash equipment is the high speed steel hardening unit. This consists of a small forge for light forging and tool dressing; an oven furnace for preheating the tools or material to a temperature of 1200 deg. F., and a high speed steel oven furnace, to which the material is transferred for the final hardening heat. The high speed steel furnace is equipped with carbofrax hearth and supports, which have a high heat conductivity and high mechanical strength, enabling the furnace to stand up under the severe service demanded in such work. The gas carburetor at the right of the furnace aids in the maintenance of a soft reducing atmosphere within the interior at all times. Gas fuel is used entirely for the high speed steel work.

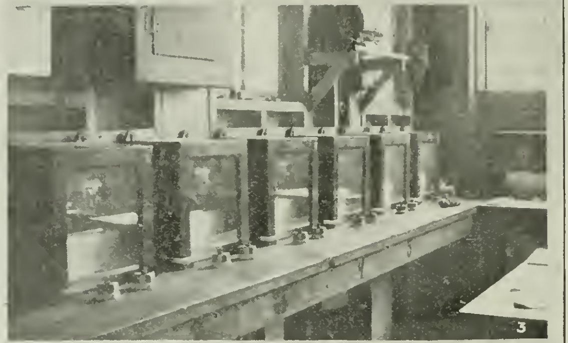
The temperature control system is very complete, and consists of 17 Leeds & Northrup indicating, recording and signaling pyrometers, housed in the office just to the right of the west entrance. This system consists of the pyrometer in the office and an indicating dial on the top of each furnace, with a plus or minus scale of 50 deg. F., together with three different colored lights which light or go out upon a 15 deg. plus or minus variation from the predetermined temperature.

The work going through this plant consists of the spline shafts, axles, drive shafts, forgings, or all parts of the car requiring heat treatment, except the transmission gears, which are hardened in a separate department by the Hump method.

All parts to be carburized are delivered to the packing room just east of the main room, where they are packed and loaded onto the cars ready for placing in the ovens.

All parts to be annealed are sent directly





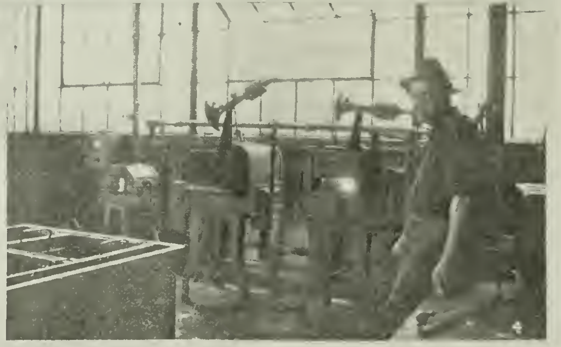


Fig. 2—There are eight heat treating ovens similar to those in the above illustration. Four quenching tanks are provided. These tanks are filled with water, but in one end of each is suspended a two-foot cylindrical oil tank.

Fig. 3—Seventeen Leeds & Northrup indicating, recording and signaling pyrometers are housed in the office for control of all the furnaces.

Fig. 4—The high speed steel hardening unit consists of two preheating furnaces and a high speed steel hardening oven and a quenching tank similar to the one shown in Fig. 2.

to the furnace scheduled to do the work, and for this work the heat treating ovens are also put into service, as they are semi-muffle and can handle small pieces very readily.

All parts to be hardened, such as differential spiders, axles, etc., are delivered into allotted spaces in the main corridor, or on an industrial railway car to the furnace; and, after being hardened, they are placed in boxes or trucks, depending upon their size, and delivered to the oil and lead tempering furnaces just to the left of the entrance, or are transferred to the inspection department in the main plant just adjoining.

The entire furnace equipment for this plant consists of Stewart Industrial Furnaces, supplied by the Chicago Flexible Shaft Company of Chicago.

Russian Iron and Steel Industry

Some Recollections on Iron Mines, Coal Fields and Steel Mills of Russia Before the War.

By VALENTINE J. GUDKOV, E.M.

FIRST of all, let us consider the deposits of iron ore in Russia. The general reserves of iron ores in that country were estimated by the Russian Geological Survey in 1910 at 2,200,000,000 tons, which corresponds to 1,100,000,000 tons of pig iron. This estimate must be considered as considerably below the exact figures. It expresses only the total of the iron ore reserves in certain deposits. The extent of exploration does not permit expression in definite figures. For instance, the estimate for the immense area of Siberia, which has been explored very little for iron ore, has been placed at about 27,000,000 tons. To what extent this influences the grand total is shown by the fact that the exploration made in 1912-1914 of the three iron deposits in the Ural, Blagodat, Bakal and Kamensk raised the estimate of the iron ore reserves for the Urals from 282,000,000 tons, as calculated in 1910, to about 400,000,000 tons of ore, or more than 48 per cent.

Very conservative estimates of the explored deposits made by the speaker in 1915, gave the following figures:

Southern Russia	900,000,000 tons
Ural Mountains	500,000,000 tons
Central Russia	900,000,000 tons
Siberia	100,000,000 tons
Caucacus	20,000,000 tons

A grand total of 2,420,000,000 tons of iron ore, or 1,200,000,000 tons of pig iron.

However, as a matter of fact, the large total reserve credited to the Central Russian District is less important than it seems, due to the thinness of the ore bodies.

From an international point of view, the ore deposits of Southern Russia are the ones which require most attention. These reserves are chiefly ores of two types, which have also a different geographic distribution. They are:

1. Hematite, which occurs in conjunction with metamorphic schists in the region of Krivoij Rog. These ores range from 50 per cent to 70 per cent metallic iron, with .01 to .06 phosphoric acid, 2-11 per cent silica, 7-35 per cent aluminum and traces of sulphur, lime and magnesia less than 1 per cent and manganese from .02 to .08. They were extensively worked until November, 1917, and there still exist 100,000,000 tons that will grade over 62 per cent iron, and 300,000,000 tons with 50 per cent metallic iron.

2. In the Kertch Peninsula deposits of poorer grade ores are found, but their relatively low iron content (around 40 per cent) is partially offset by advantages of location, and by the large tonnage available, estimated at some 500,000,000 tons. The ores are brown hematites associated with Pliocene beds, and range from 38 per cent to 42 per cent in iron, 1 per cent to 8 per cent manganese, 1.5 per cent to 2 per cent phosphorous and 14 per cent to 17 per cent silica.

In the Urals, with the exception of the Bogoslovsk Mining District, iron ore deposits have not been explored. We can mention here the Comarovsky Deposits with 100,000,000 tons of brown hematite of 55 per cent metallic iron, Bfagovfinsky with 75,000,000 tons of ore with 58 per cent of metallic iron, Bakal with 75,000,000 tons of brown hematite with 60 per cent metallic iron, Blagodat with 50,000,000 tons of magnetic ore of 65 per cent metallic iron, and several others ranging from 50 per cent to 68 per cent metallic iron. Vast stretches in the Southern and Northern Urals are absolutely unexplored and undeveloped, but geological data furnishes a basis for the belief that further prospecting and exploration will lead to the discovery of additional deposits of iron ores.

In Siberia several centers of iron industry have been definitely indicated. The biggest deposit is situated in Kufnesky District, which was fully explored by Professor Gudkov of the Tomsk University. At the Southeastern border of this district, near Lake Teletsk, are deposits of 68 per cent magnetic, the extent of which is very conservatively estimated at 25,000,000 tons.

Within the boundaries of the Kirkif Steppes there are deposits of hematite and magnetic ores containing 60-63 per cent metallic iron, which amount to 25,000,000 tons. In the Enisei District there are a series of iron ore deposits, chiefly magnetic ore. Of these the most thoroughly explored are Abakansky with 3,000,000 tons of 70 per cent magnetic ore, and Trbinskog with 8,000,000 tons. In Irkutsk District the iron ore deposits are magnetite of 58-65 per cent iron, which stretch northward from the line of the

Siberian Railroad along the River Angara and its tributary the Oka. The amount of ore in the four deposits that were worked for a few years was estimated at 10,000,000 tons.

On the Far Eastern Coast a considerable amount of iron is indicated in the Primarskoje District near Olga Bay and Vladimis Bay, where a number of deposits of magnetite with up to 60 per cent of iron are known. The amount of that ore is estimated at about 8,000,000 tons.

The Caucasus is more productive of non-ferrous metals than iron. However, at Chataksy, six miles from Tiflis Darkessen, twenty miles from Elizavetport, there are several deposits of hematite ore, with 65,000,000 tons of 60 per cent magnetite. Other ores are also found there.

Man-power, supplemented by domestic animals, carried out all the mining operations. The pick and shovel removed the earthy covering and subsequently the ore was hauled away from the opening to ore dumps in wagons or carts to the railroad cars. Underground mining was conducted with the same crude appliances. Beginning in 1910, considerable progress was made in mining, altho there was nothing special that would be interesting or new to the American miner.

The average price in the Ural Mountains for one ton of ore, 55 per cent, was $3.00 fob. mine. In Southern Russia it was between $5.00 to 6.00. It is interesting to note that several Ural Mills were equipped with special furnaces for working the magnetic ore, in order to transform magnetic oxide to ferric oxide. Ore was crushed partly by hand and partly by rock crushers. Magnetic concentrates hardly existed, with one exception—the Vidlitsky Mines in Northern Russia. Agglomeration was practiced at Vidlitsky and Kerchensky works with satisfactory results.

Coal Fields of Russia.

The deposits of coal in Russia are all in the more or less explored districts—namely Donetsky, Uralsky and Kuznetzky. Out of the total deposits of pit coal in the Donetzky region, amounting to more than 65,000,000,000 tons, the proportion of bituminous coal is about 18,000,000,000 tons. If we take into consideration the fact that from the time of the discovery of the Donetzky Coal District, up to the present day, the total quantity of coal mined is estimated at not more than 300,000,000 tons (less than 2 per cent of the total deposits), then we can see clearly that the time to speak of the exhaustion of the coal deposits in the Donetzky District has not yet arrived.

The Ural region is in a less favorable position. Thus far deposits of coking coal have not been discovered, although pit coal and lignite were mined in several places—Abamelek, Lafareff, Bogoslovsky and Agilrky, together with a few others.

The Kuznetzky District in Siberia was thoroughly explored by the teacher of the speaker, Mr. Lootoogine, one of the most prominent Russian Coal Geologists. The object of his exploration was to obtain data for the purpose of compiling a geological map of the district, and it has now been proved that the Kuznetzky District contains deposits of coking coal of a magnitude far surpassing that of the Donetzky coal reserves. The aggregate thickness of the Kuznetzky coal vein, comprising six distinct beds, is 300 feet, whereas the total thickness of the Donetzky coal bed is only 70 feet.

After some preliminary exploration, the Kuznetsky Company began, in 1913, to equip two main coal mines, the Kolchugino and the Kemerovo mines. Coal mined in 1913 amounted to 10,000 tons; in 1914, 50,000 tons; 1915, 70,000 tons; 1916, 210,000 tons and for 9 months of 1917, 250,000 tons. At Kolchugino mine four flat dipping veins of cherry coal were marked, having a respective thickness of 3.5 feet, 1, 8, 7 and 14 feet. At Kamerovo mine the coking coal beds were under exploitation as follows: one at a thickness of 35 feet, one at 14 feet and two at 7 feet, the angle of the dip being 45 degrees. In the neighborhood of Irkutsk there was the Cheremkorsky mine, with an annual output of 1,000,000 tons of non-coking coal; and in the region of Vladivostock, the Suchan mine, having an annual output of 40,000 tons of non-coking coal.

Excepting Kamchatka and the region to the north of it, there are several deposits of bituminous and brown coals. All of the former are of the Furassic period. The brown coals are upper Tertiary. On the island of Saghalin and in Kamchatka the coal bearing strata are much the same as in Japan, Canada and Alaska. The value of the deposits on the mainland is purely local, whereas Saghalin coal might become of world wide importance could the development and transportation difficulties be solved.

Most of the Donetzky seams are of high dip and therefore they are usually opened from a vertical shaft by rock tunnels driven at regular intervals.

Steel Mills of Russia.

Steel mills of Russia may be divided into four groups as follows: 1. Northeastern and Baltic group, with Petrogad as the center; 2. The Urals; 3. The Central group with Moscow as the center; 4. The Southern group.

In 1913 the production in long tons of these groups was as follows:

	Pig	Bessemer	O. H.	Beams & Shapes	Plates & Sheets	Rails
1	500	....	168.500	175,430	36,500	180
2	923,700	45,100	890.500	244,340	277,700	133,440
3	250,900	100	243,000	198,780	104,830	0
4	3,101,290	750,900	2,031,200	1,268,700	448,700	4,740
Totals	4,276,390	796,100	3,333,200	1,887,250	867,630	138,360

The Pig Iron in group No. 1 was produced at Segovetz in the Government of Olonetz, by cold blast, in small charcoal Blast Furnaces. The burden was a mixture of carbonate and magnetite, with an average content of 50 per cent metallic iron. The steel ingots, 113,300 tons—of which the Poutiloff Works of Petrograd produced 70,800 tons—were made in five private and three Governmental Works. The Poutilovsky mill was employing 12,000 men who were engaged in building ships, making guns, shells, locomotives, cars, tool steel of very high quality, shapes, ingots and so forth.

The Pig Iron in group No. 2 was produced by some twenty private companies, 761,200 tons, and 12 government plants, 162,500 tons; the open hearth steel by 19 private plants, 809,100 tons, and 13 government plants, 81,400 tons. Some of these plants, both private and state owned, produced puddled iron (23,608 tons); steel (3,970 tons), and one plant of Nizny Ialda produced Bessemer ingot (45,100 tons). Flatuurt government plant crucible and electric steel production amounted to 430 tons, besides the tonnage given in the above table.

All the pig iron was produced with charcoal, except in the furnaces of the Bogoslovsk Mining Company, who used dried raw wood, and a mixture of raw wood and charcoal. There was no coking coal in this region, which was the cause of the low output of blast furnaces. The largest tonnage of a single blast furnace did not exceed 125 tons per day, and the smallest on cold blast was as low as 15 tons a day. The fuel for the open hearth furnaces was raw wood, and in Bogoslovsky district brown coal and blast furnace gas.

The mineral wealth of the Urals cannot be developed to the fullest extent until coke can be delivered to the blast furnaces more cheaply than at present, either by rail or water.

In 1913 the six largest producers of both pig iron and steel were as follows:

	Pig Iron	Steel Ingots
Bogoslovsky	169,300	180,000
Demidovsky	91,000	53,800
Alapaevsky	58,700	40,000
Kamsky	56,200	78,100
Balasheff	53,000	20,800
Shouvaloff	51,800	57,000

In group No. 3, including the Moscow District, the largest pig iron producer was the Belgian Company of Tamboff, with 115,400 tons of pig iron per year. The open hearth steel was produced by four plants, their shares ranging from 48,000 tons (Viksa Company) to 69,400 (Googon) Moscow. The Bessemer steel was made in the Sormovo Works, near Nizny-Novgorod. This plant and Kolomensky Locomotive Works of Moscow, also turned out 10,700 tons of high grade steel castings, not included in the tonnages of our summary table. It was at the Moscow plant—Googon—that the first tinplate mill in Russia was installed 20 years ago. The five open hearth furnaces at that mill are fired with crude oil. The Viksa Company, in the Government of Nizny-Novgorod, was a German concern. Its chief product was merchant bars and certain special products.

Group No. 4, or the so-called Southern group, forms the backbone of the Russian iron and steel industry, producing about 75 per cent of the total output of pig iron, 60 per cent of all the open hearth steel and 94 per cent of the Bessemer ingots.

The aforementioned tonnage was produced by about fifteen companies. The blast furnaces belonging to this group consumed 3,680,000 tons of coke in producing the 3,100,200 tons of pig iron, ferro-manganese, spigel, ferro-silicon and so forth.

As the whole of the coke output of the Donetzky District was about 4,500,000 tons there remained 800,000 tons of coke for the furnaces of group No. 3 and the foundry works of Petrograd, Moscow and elsewhere. The blast furnaces of Kertz Peninsula were running on English coke, which necessarily increased transportation difficulties. One of the most up-to-date plants is that of Briansky at Ekaterinoslav, with six blast furnaces having a total capacity of 2,400 tons a day, with bucket charging system designed and built by Nikolai Nikolay Gogozky, general superintendent of this plant. Six gas blowing engines supply the necessary blast, with four steam blowing engines in reserve. Electric current, 3-phase 3,100 volts, is generated by Curtis steam turbines, fed by boilers fired with clean blast furnace gas. The total output of five generators is 150,000 kw, of which 10 per cent is transformed into direct current. All the rolling mills, except blooming and rail mills, are driven by electric motors. The latter are still driven by reversible steam engines 4,000 and 5,000 hp respectively.

The Bessemer plant includes three converters of 12 tons each, with a 400-ton mixer heated with blast furnace gas. The open hearth consists of 4—30-ton furnaces, 2—40-ton and 1—50-ton, with a mixer of 200 tons. A plant furnishing 10,000,000 slag bricks per annum was completed in 1914.

Among the other plants the most important are Dnieprovsky, Russian-Belgian, Novorossisky, Makeevsky, Drojkovsky, Ktrchensky, Nicopol-Marinpolsky, Donetzky and Lsoolinsky.

THE PRESIDENT'S CONFERENCE ON UNEMPLOYMENT

Recovery of our industry and employment must necessarily be a process of gradual healing of the great economic wounds of the World War. This healing is making distinct progress.

Without attempting the impossible task of assessing the relative weight of different forces, the conference presents the following summary of the more important matters that require constructive and immediate settlement, if recovery in business and permanent employment are to be more expeditiously accomplished.

1. Readjustment of railway rates to a fairer basis of the relative value of commodities, with special consideration of the rates upon primary commodities, at the same time safeguarding the financial stability of the railways.

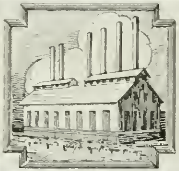
2. Speedy completion of the tax bill, with its contemplated reductio nof taxes, in order that business now held back pending definite determination may proceed.

3. Definite settlement of tariff legislation, in order that business may determine its future conduct and policies.

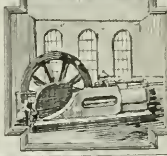
4. Settlement of the financial relationships between the government and the railways, having in mind the immediate necessity for increased maintenance and betterments, making effective increased railway employment and stimulation of general employment, in order that the railways may be prepared for enlarged business as it comes.

6. Steps looking to the minimizing of fluctuations in exchange, because recovery from the great slump in exports (due to the economic situation in Europe) can not make substantial progress so long as extravagant daily fluctuations continue in foreign exchange, for no merchant can determine the delivery cost of any international shipment.

7. Definite programs of action that will lead to the elimination of waste and more regular employment in seasonal and intermittent industries, notably in the coal industry, in order that the drain upon capital may be lessened and the annual income of workers may be increased.



STEAM POWER DEPARTMENT



Boiler Water Treatment Plant

Several Important Methods of Water Treatment Are Considered —Resultant Operating Tests Are Included Showing the Saving Brought About.

By ROBERT JUNE, M. E.

PART III

OUR two preceding articles have dealt with the various impurities in boiler feed water, the resultant operating troubles, and we have also considered the use of boiler compounds, boiler metal treatment and water softening plants, as a means of overcoming our difficulties. Several important methods of water treatment have yet to be considered.

Permutit.

All of the troublesome calcium and magnesium in boiler feed water may be removed by passing the water through a bed of zeolite. This is an artificial hydrous silicate produced from clay, felspar, soda ash and pearl ash. A zeolite possesses the valuable property of effecting a rapid exchange of the sodium which it contains for the calcium and magnesium in the water. As hard water is passed through the softening bed the exchange takes place, harmless sodium salts being formed, and the hardness remaining in the zeolite.

The action is a chemical exchange and not a reaction. There is of course a definite limit to the quantity of sodium salts which may be exchanged for the hard calcium and magnesium in the water, this limit depending upon the size of the zeolite bed and the quantity of water passed through it. When the limit has been reached the zeolite bed is regenerated by passing through it a brine composed of common salt. As the reverse of the softening exchange takes place, sodium replaces the destructive minerals and the waste material is carried off to the sewer. The zeolite bed is then ready to treat another batch of hard water. As the exchange involves no loss of the zeolite, the same bed may be used for an indefinite number of years without the addition of a new supply of zeolite.

Permutit is the trade name of a specific form of zeolite, and a specific design of equipment. In the Permutit system the raw water is delivered to the top of a closed tank and is caused to percolate successively through a layer of crushed marble, Permutit and gravel. This filtration effects the necessary purification.

The design of a particular Permutit system will of course depend upon the chemical composition of the water to be treated and the maximum hourly and total daily amounts. The area of the filter and the depth of the layers must therefore be determined in each individual case, after the water has been analyzed and the desired capacities determined. It is extremely important in connection with the installation of a system of this character to be sure that sufficient allowance is made for all possible contingencies, as the capacity of the system is definitely limited and cannot be exceeded with satisfactory results.

In the main, the rate of filtration through a Permutit bed is as fast as that found in a rapid sand filter, consequently the equipment does not take up a large amount of floor space in relation to the quantity of water handled.

It is the general practice in the design of this equipment to pass the water down through the filter bed. Operating valves are provided so that during the process of regeneration the flow may be reversed, thus thoroughly loosening and carrying upward all exchanged material and sediment deposited in the down flow. By reversing the flow in this manner any tendency of the water to form channels in the filter bed is removed.

When a continuous night and day supply of water is desired, it is necessary to either arrange for the storage of water or for a duplicate set of filters. In regenerating the zeolite bed the water is first drained down to about the upper surface of the Permutit bed. In general a 10 per cent salt solution is employed. This solution is allowed to flow slowly upward through the filter, a number of hours being allowed for the process. In order to cleanse the filter of the salt solution, two or three gallons of water are required for every pound of salt. The outlet cock at the bottom is opened and the filter filled with fresh water. About twenty or thirty minutes are usually required to remove the salt solution, the washing lasting until the water no longer shows any hardness when tested with standard soap solution, as described in one of our preceding articles.

Because of its positive character, Permutit offers a real solution to the feed water problem. Boilers and auxiliary apparatus are found to be maintained permanently clean when water which has been treated by this process is utilized. The initial investment in equipment of this sort is of course a factor which is to be considered. However in view of the large amount of capital necessarily tied up in boilers and auxiliaries, it is well worth while to consider the use of a zeolite system under difficult water conditions.

Borromite.

Zeolite may be classed as slow-acting or rapid-rate. Borromite, a specific trade name of another zeolite softening process is of the rapid-rate type.

The difference between a slow-acting or rapid-rate zeolite may be illustrated by the following example: The slow-acting zeolite softener may have a total capacity of 1,000 gallons. The time required to realize this capacity is from 10 to 12 hours, and the rate at which this capacity of soft water can be realized is uniform and may not be exceeded. In other words, the normal, maximum rate per hour cannot exceed 100 gallons, or one-tenth of the total capacity.

The rapid-rate zeolite, having a capacity of 1,000 gallons, may deliver this quantity of water in as short a period as 1¾ hours. The rate at which the water may be delivered is not restricted by the element of time which enters into the reaction which takes place with the slow-acting zeolite.

Zeolite Plants from an Investment Standpoint.

The figures in Table I have been tabulated for a small steam plant operating three 200-hp boilers, average load 500 bhp., peak load 750 bhp. Make-up amounts to 50 per cent of the total boiler feed. This data is from average figures based on the experience of Borromite users.

TABLE I.

(Coal at $5.00 per ton in the firebox.)

Cost of Operation with Scale.

(1) Make-up water is 12 grains per gallon in hardness. Scale in 3 weeks is 7/64 in. thick—average about 1/16 in.; loss in heat is 10 per cent. Boilers opened for cleaning and inspection every 3 weeks.	
(2) One of the 3 200-hp boilers is cleaned each week. Labor cost—2 men, 2 days at $5 per day, per annum	$1,040.00
(3) Coal for heating the water drained out of boiler and that to fill boiler after cleaning—¼ tons × 52 weeks × $5 (13 tons) per annum	65.00
(4) Investment in a Boiler and Stoker—$5,000.00. Since a boiler is out of service 2 days each time it is cleaned, this means with 3 boilers there are 104 days one is out of use in a year. ($5,000 × 7% × 104) ÷ 365 = interest loss on investment	99.00
(5) Excess blow-down over normal, to eliminate sludge from use of boiler compound, and hard water is 2 gauges extra per day or 310 gallons total for three boilers. (310 gal. × 8.3 lbs. = 210° [rise in temperature] × 365 days × $5.00) ÷ (8,400 [Btu per lb. of coal] × 2,000 lbs.) =	58.70
(6) New tubes, 12 per boiler or 36 at $10.00 per annum	360.00
(7) Coal, 1,400 tons at $5.00—per annum	7,000.00
Total	$8,622.70

Summary:

Cost of operation with scale	$8,622.70	
Cost of scale-less operation	6,416.50	
Gross annual saving		$2,206.20
Cost of Borromite Softener for plant of this size—$3,000.00.		
Interest and depreciation at 15 per cent	$450.00	
Cost of operation, 26 tons salt at $10.00	260.00	
		710.00

TABLE I.

(Coal at $5.00 per ton in the firebox)

Cost of Scale-Less Operation with a Borromite Water Softener.

(1) Make-up water is 0 grains per gallon in hardness. No scale is formed. Boilers opened for inspection once every 12 weeks.	
(2) No scale, no labor cost for cleaning—per annum	$ 00.00
(3) Coal for heating the water drained out of boiler and that to fill after inspection. ¼ ton × 12 months × $5.00 (3 tons) per annum	15.00
(4) Investment in a Boiler and Stoker—$5,000.00. Since a boiler is out of service 1 day each time it is inspected, this means with 3 boilers there are 12 days one is out of use in a year ($5,000 × 7% × 12) ÷ 365 = interest loss on investment	11.50
(5) No excess blow-down with clean soft water	00.00
(6) New tubes, 3 per boiler or 9 at $10.00—per annum	90.00
(7) Coal, 1,400 tons—10 per cent (140 tons) or 1,260 at $5.00	6,300.00
Total	$6,416.50

Summary (Continued):

Gross annual saving	$2,206.20
Less interest and operating charges	710.00
Annual "Pay-Balance," Net	$1,496.20
Return on investment in Softener	50%

Distilling Plants and Evaporators.

Distilled water for boiler feed is in successful use in many power plants. It is first produced by vaporizing the raw water in an evaporator, and then passing the steam to a condenser, or preferably into the boiler feed heater, where it is condensed by means of the feed water entering from the main power plant condenser.

The Reilly Submerged Type Evaporator, consists, essentially, of a closed shell for holding the raw water, into which are introduced a number of steam coils. Live steam from the boiler, sometimes at reduced pressure, or auxiliary exhaust steam, is passed into the coils where, upon condensation, it gives up its latent heat to the raw water, thus vaporizing the raw water.

In order to effect greater economies in operation "double effect" distilling plants are frequently used.

In this type of plant steam from the "first effect" evaporator is condensed in the heating coils of the "second effect" evaporator, the vapor from the "second effect" evaporator being condensed in the usual way.

As a matter of general practice it will be found that the production of the "single effect" distilling plant is approximately one pound of distilled water for one and two-tenths pounds of steam supplied to the evaporator coils, whereas the "double effect" distilling plant will produce about one pound for each seven-tenths pounds of steam supplied to the "first effect" evaporator coils.

Therefore, in choosing between the "single effect" evaporator and the "double or multiple effect" evaporator, consideration is to be given to first cost on the one hand, and to the economies effected by the use of the compound equipment on the other. From a dollars and cents standpoint it is usually more economical and better engineering practice to use the "double" or "multiple effect" system.

Evaporating plants are generally designated as "low heat" level or "high heat" level. In the "low heat" level plant the evaporators may be operated with boiler steam at full or reduced pressure, or with auxiliary exhaust steam at a pressure as low as two pounds. The latter installation, where auxiliary exhaust steam is used, is apt to be quite expensive however, owing to the large volume of steam handled and to the fact that evaporation must take place under a vacuum, thus requiring vacuum pumps, etc.

Where there is say 10 per cent or more of make up water required and where economizers are not used, it will generally be found that the "high heat" level evaporating system is the most satisfactory and economical. As the name indicates, evaporation in this system takes place at comparatively high temperatures and pressures. As the steam consequently passes from the evaporator at high temperatures it can be condensed in a condenser, using circulating water at correspondingly high temperature.

In the Griscom-Russell Company "high heat" level condenser the boiler feed is pumped from the boiler feed heater through the "high heat" level condenser or condensers, on its way to the boilers. Drains from the "high heat" level condenser and from evaporator coils are passed to the boiler feed heater. With this system the boiler feed water re-absorbs all heat given up in the evaporating coils with the exception of the small amount lost in radiation and the evaporator blow off.

Distilled water is of course of zero hardness and its use assures the absolute elimination of any impurities in the feed water, so that exceedingly high boiler ratings can readily be obtained and consistently maintained by the use of distilled feed water.

The analysis in Table II. of probable savings in plant operation by the use of the evaporator system is based on figures supplied by the Griscom Russell Company.

TABLE II.

Net hourly boiler evaporation	150,000 lbs.
Net hourly boiler feed make-up	15,000 lbs.
Net hourly boiler blow (without evaporator system)	7,500 lbs.
Boiler steam at 200 lbs. gauge, saturated.	
Hot well temperature	90° F.
Raw water which would be used for evaporator feed	63° F. (Brackish)
Auxiliary exhaust steam, 13,500 lbs. per hr. at 0 lbs. g.	
Boiler evaporation, 9 lbs. of steam to 200 lbs. g. per lb. of coal (Useful heat per lb. of coal = 10,513 Btu).	
Cost of coal	$4.00 per 2,000 lbs.
Cost of present make-up water $1.00 per 1,000 cu. ft. (Purchased from Public Water Works)	63°

Boiler Blow—

Will be practcially eliminated.

Savings per year =

$$\frac{7{,}500 \times 330 \times 8{,}760 \times \$4.00}{10{,}513. \times 2{,}000} = \$\ 4{,}124.00$$

Boiler Tube Heat Transfer—

Will be increased sufficiently to save approximately 5 per cent of coal bill.

Saving per year =

$$\frac{150{,}000 \times 8{,}760 \times .05 \times \$4.00}{9 \times 2{,}000} = 14{,}600.00$$

Boiler Take Down—

Will be largely eliminated.

Estimated saving per year 1,000.00

Boiler Maintenance—

Tube replacements, etc., will be greatly reduced.

Estimated saving per year 500.00

Cost of Present Make-up Water—

Will be eliminated.

Saving per year =

$$\frac{15{,}000 \times 8{,}760 \times \$1.00}{62.5 \times 1{,}000} = 2{,}100.00$$

Total yearly savings in plant operation = 22,324.00

CHARGES AGAINST EVAPORATOR SYSTEM.

First Cost—

Approximate total cost of Evaporator System, includinng piping, lagging and erection .... $ 26,900.00

Radiation—

Approximate total radiation surface = 800 sq. ft.

Assuming radiation = 60 Btu per sq. ft. per hr.

Heat losses per hour = 800 × 60 = 48,000 Btu.

Evaporator Blow—

With the system proposed, evaporator blow will be about 2,500 lbs. per hour at 212° F. (Temp. of raw feed 63°).

Heat losses per hour = 2,500 × 149 = 373,500 Btu.

Total heat losses per hour = 421,500 Btu.

$$\frac{421{,}500 \times 8{,}760 \times \$4.00}{10{,}513 \times 2{,}000} = 703.00$$

15 per cent per year on $26,900....... = 4,035.00

Yearly labor charges for evaporator system .... = 1,000.00

Total yearly charges against evaporator system .... = $ 5,738.00

Conclusions—

Total savings in plant operation per year $22,324.00

Total charges against evaporator system per year 5,738.00

Net yearly balance.................... $16,586.00

Meeting of the American Electro Chemical Society

Report of the General Meeting Held at Lake Placid, N. Y., September 29 to October 1, 1921—Papers of Interest to the Iron and Steel Industry Presented.

THE general meeting of the American Electro Chemical Society, recently held at Lake Placid, Adirondack Mountains, was considered by all those present to have been one of the most enjoyable of any of the meetings held by that society. The mornings of the days of the convention were devoted to the reading of technical papers while the afternoons were spent in a social way.

During the course of the meeting, a number of papers of interest to the iron and steel industry were presented. Abstracts of some of the most interesting follow:

"Recent Developments in Electric Furnaces of the Muffled Arc Type." H. A. Winne. Several types of muffled arc melting furnaces are described with their features and adaptabilities.

"Electric Furnace Purification of Zirkite." J. G. Thompson. The arc type furnace used in this investigation made it possible to remove 90-95 per cent Si as an impurity from the Zirkite ore; the amount of carbon introduced being only sufficient to transform the silicon to the carbide.

"Physical Characteristics of Specialized Refractories. Cross Breaking Strength at 20° and 1350° C." M. L. Hartman and W. A. Koehler. The tests were carried out on each of 10 refractory materials at the temperatures indicated.

"The Influence of the Electric Furnace on the Metallurgy of Non-Ferrous Metals." H. M. St. John. The use of the electric furnace in brass foundries and refining plants for melting purposes has revolutionized metal handling methods; a more uniform quality of product is obtained with less labor and less metal wastage. The attainments are better than have been previously possible and the secretiveness which has been characteristic of the non-ferrous industry is gradually being done away with.

"Modern Developments in the British Brass Industry." E. H. Smith. The actual conditions of the British brass industry are presented with a discussion of electric brass furnaces, hot pressing and forging of brass, rolling mill practice, annealing, etc.

"Resistance Type of Electric Furnace in the Melting of Brass and Other Non-Ferrous Metals." T. F. Bailey. The various features to be considered in making an electric furnace installation for melting non-ferrous metals are discussed.

"Comparison of Electric Furnace Practice with Fuel Fired Furnace Practice." N. K. B. Patch. The author's experiences are that the cost of metal melted, the melting losses, and the solution of gases in metal, are substantially the same in the electric and the fuel fired furnace, provided intelligent operation is pursued.

"A New Theory of the Corrosion of Iron." J. Newton Friend. An auto-colloidal catalytic theory, which postulates the corrosion as starting by the formation of colloidal ferrous hydroxide. This by contact with the air forms hydrated ferric hydroxide which in turn is alternately reduced by contact with iron and oxidized by contact with air, thus continuing the corrosion.

"Rust Prevention by Slushing." Haakon Styri. An extended research which shows that for protection against rust by greases a thorough cleaning of the steel parts by an aqueous solution is essential: an oil emulsion which leaves an oil film for short time protecton is preferable. Such emulsions protect against rust.

"Transformer Oil Sludge." C. J. Rodman. Of the three types of transformer oil sludge (asphaltic, soap and carbon), the asphaltic is the most general form and is the exidation product of an attackable oil. It collects upon the active parts of transformer. The soap sludge forms slowly and is difficult to remove by filtration. The carbon sludge is caused by electrical breakdown.

"An Electric Steam-Generator for Low Voltage." F. A. Lidbury and F. A. Stamps. An inexpensive form of apparatus for the generation of steam by means of an alternating current of voltages from 100 to 500.

"The Effect of Pressure on Overvoltage." H. M. Goodwin and L. A. Wilson. The values of overvoltage of hydrogen against copper, nickel and mercury electrodes were determined at pressures varying from one atmosphere to a few centimeters of mercury.

"Researches on the Electrodeposition of Iron." W. E. Hughes. The results of several experimenters and those obtained by the author are related in three electrodeposition of iron from (1) sulphate solutions, (2) chloride solutions and (3) sulphate-chloide solutions.

STEEL FOUNDRYMEN APPROVE CO-OPERATIVE PLAN

Officers and operating heads of five steel casting companies which have been associated in research work to which Major R. A Bull, Sewickley, Pa., devotes all of his time for the benefit of the co-operating companies, recently held a meeting at Wernersville, Pa. The companies which specialize in the manufacture of small steel castings and which were represented at this meeting include the Lebanon Steel Foundry, Lebanon, Pa.; Fort Pitt Steel Castings Co., McKeesport, Pa.; Michigan Steel Castings Co., Detroit; Electric Steel Co., Chicago, and the Sivyer Steel Castings Co., Milwaukee. At the beginning of their co-operative work these companies established uniform standards of inspection and after a years' experience in adhering to these standards unanimous approval was expressed at this meeting concerning this method of obtaining a uniform and satisfactory product.

PRODUCTION TOPICS

OUTLINE OF A PRACTICAL COURSE IN STEEL MAKING.

By P. S. Young.

(Continued form October issue)

In making out these papers they should be able to call on the help of the man who has been overseeing the work in that department. He will doubtless be able to clear up some very necessary points which they have overlooked or not thoroughly understood, thus giving them a comprehensive view of the main workings of the department. This paper should be written in three days time or less, and while writing it the men should do nothing else.

During their course, if any experimental work is being done or tests made, they should be present to witness it or take an actual part in it.

Item 4. Contract between the student and company.

If the proper selection has been made, and a man has gone through the course successfully, he should be assured of a good wage, as he is now in mental and physical condition to do many jobs well. He should be consulted as to the department in which he prefers to work, and the first opening in keeping with his knowledge and experience should be given him. If the management does not feel he is capable of it, the selection for the course was undoubtedly bad, and should have been discovered long before. If he does not show sufficient executive ability when given the opportunity of handling men, his ability to have stood through the course and his experience in the steel works should fit him splendidly for the sales or purchasing departments.

During the course he should be graded on the following points:

1. Ability (general).
2. Adaptability.
3. Perseverance.
4. Willingness to work.
5. His relations with fellow-workmen.
6. Habits (proper).
7. Habits as to regularity and punctuality.
8. Examination grades.
9. Final examination in each department.
10. Thesis on each department.

The following is a trial outline of the course:

Blast Furnaces.

(30 weeks)

Car dumper and larry cars	1 week
Ore bridge and skip hoists	1 week
Stock cars under trestle in stock house	1 week
General work around stock house, going rounds with S. H. Foreman	1 week
Pipe fitting gang at blast furnaces	2 weeks
Labor gang at furnaces (cleaning stoves, scrapping runners, snapping cinder, unloading scrap, wheeling tools, changing tuyeres and all repair work)	1 week
Helper on furnace	1 week
Keeper on furnace	3 weeks
Hotblastman (stoveman)	3 weeks
Watching blower	1 week
As blower (not in actual charge of furnace, but making all the decisions and being told by blower where wrong)	2 weeks
With turn foreman (going around with him in all his work)	1 week
At gas plant working around gas scrubbers, separators and washers	3 weeks
In blowing rooms	2 weeks
At pig machine. (If pig machine is not in regular operation, six of its operating days may be picked while student is in blast furnace dept.	1 week
On blast furnace, bricklayers gang doing brick repairs around the furnaces and studying their prints of blast furnace lining and construction of stoves	4 weeks
In blast furnace office with clerk making out log book reports, all other reports and burden sheets. Last three days of this time writing thesis	2 weeks
Total	30 weeks

Open Hearth Department

(35 weeks)

Stock yard as stocker	2 weeks
Weigh offices	1 week
Ladle liner helper	3 days
Nozzle setter helper	3 days
Stopper setter helper	1 week
Third helper on furnaces	3 weeks
Second helper on furnaces	4 weeks
With first helper (as with blower at blast furnaces)	4 weeks
Following melter foreman all day	1 week
Steel pouring gang	4 weeks
Open hearth bricklayer gang	8 weeks
Gas producers (if natural or by-product gas, oil or tar is used, time at producers should be distributed between floor and pouring platform)	3 weeks
Mixing house pans and crushers	1 week
Calcining cupolas	3 days
Open hearth office (making reports, general office work)	1 week
Writing thesis	3 days
Total	35 weeks

Bessemer Department

(6 weeks)

If there is no Bessemer department distribute this time between the open hearth floor and platform work	1 week
Metal mixer	1 week
Vessel gang	2 weeks
With regulator in blowers pulpit	1 week
As regulator	1 week
Total	6 weeks

Blooming Mill Department

(18 weeks)

Blooming mill office (learning to make out tonnage reports, dealing with orders coming in and orders filled and how orders are booked and distributed)	1 week
Steel distributor to the different pits	1 week
Soaking pits as bottom maker's helper	1 week
With heater	3 weeks
Mill recorder's office	1 week
Roller's pulpit	3 weeks
Billet mills on stands and shears	3 weeks
Bricklayer gang on soaking pits	3 weeks
Roll shop	3 week
Office and writing thesis	1 week
Total	18 weeks

Finishing Mills Department

(14 weeks)

(There is such a diversity of finishing mills that this section of the course should be made out by the department head where the above course designed for rod mills falls short.)

NEWS OF THE PLANTS

The Harrisburg Bar Mill Company, Harrisburg, Pa., recently organized with a capital of $50,000, will operate a plant on North Sixth Street, near the city limits, for the manufacture of steel and iron bars. The rolling mill has been producing for several weeks past, running on a single shift, and as soon as conditions warrant a night force will be employed. The plant equipment comprises three oil-heating furnaces, a 12-inch merchant mill and a 9-inch merchant mill with auxiliary operating machinery. Employment will be given to about 100 men for the present. J. K. White, formerly general sales manager of the Harrisburg Pipe & Pipe Bending Company, Harrisburg, is president of the new organization, and A. L. Ensinger, also previously connected with the same company, is secretary.

The Keystone Iron & Steel Works, Los Angeles, Cal., has commenced operations at its new plant at 2931-3641 Santa Fe Avenue, comprising two main buildings, three, two and one-story in height. The company will make a specialty of steel and gray iron castings, and has installed a complete electric steel furnace department for this purpose. Other products will include a number of iron specialties and for which complete facilities have been installed.

The Columbus Forge & Iron Company, foot of West First Avenue, Columbus, Ohio, manufacturer of forgings, anvils, etc., has awarded a building contract to the Middle States Construction Company, Nock Road, for the construction of its proposed new plant additions for increased capacity. The structures will be each one-story, 70x200 feet and 100x160 feet, respectively. Foster Copeland is president

The Richard French Iron Works, Muskego Street, Worcester, Mass., recently reorganized, will commence the immediate construction of its proposed new plant on property lately purchased at Millbury, Mass. The works will consist of a main one-story building, 65x120 feet, with a number of smaller structures averaging 25x25 feet, for general iron-working and office service. Local electric power will be used, and the company will install motors and other electrical apparatus for operation. The building contract has been awarded to the E. D. Ward Company, 82 Foster Street, Worcester. A. B. Campbell is president and Raymond Tracy vice president.

Horace T. Potts & Company, 316 North Third Street, Philadelphia, Pa., iron and steel products, has awarded a building contract to William Steele & Sons, Inc., Sixteenth and Arch Streets, for the construction of a new plant at Erie and D Streets, consisting of a number of buildings, estimated to cost about $450,000, including equipment. Erection will be placed under way at an early date.

The Tomahawk Steel & Iron Works, Tomahawk, Wis., has foundation work under way for its proposed new two and three-story plant to replace its works recently destroyed by fire. A list of equipment for installation has been prepared, including traveling cranes, iron working machinery, machine tools and other apparatus. The new plant is estimated to cost close to $100,000, as compared with a previous estimate of $80,000. It will be 100x180 feet. W. Drever is president.

The Utah Iron & Steel Company, Salt Lake City, Utah, manufacturer of steel bars and other steel and iron products, is arranging an extensive expansion program at its works at Midvale, Utah. A new blast furnace will be constructed, with a number of new mills, including plate mill, bar mill, rolling mill and other structures. New shops for general production, machine work, etc., will be erected. The entire project is estimated to cost close to $3,000,000, and to carry out the details of the work the stockholders have voted to increase the capital from $2,500,000 to $5,000,000, with the addition of 50,000 shares of common stock, no par value.

The Driver-Harris Company, Middlesex Street, Harrison, N. J., manufacturer of wire, steel products, etc., will commence the immediate erection of a new one-story plant building on Somerset Street, between Third and Fourth Streets, to be equipped as a rolling mill. It will be 95x275 feet, and is estimated to cost about $35,000.

The Electric Manganese Company, Reading, Pa., care of William H. Dechant & Son, Baer Building, Reading, has plans under way for the construction of a new one-story plant in the Brush Valley Section, and plans to inaugurate work at an early date. The structure will be 40x140 feet, and is estimated to cost close to $55,000.

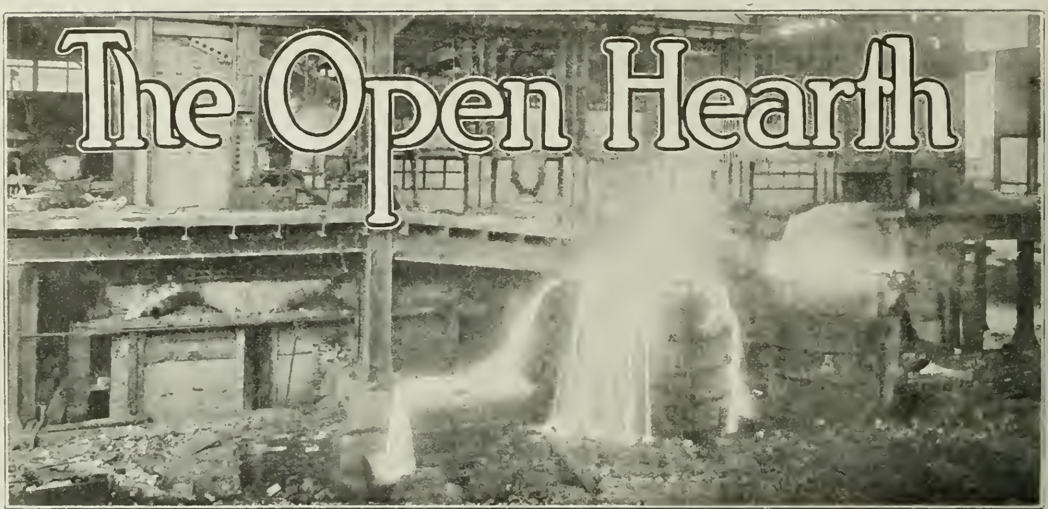
The Wyckoff Drawn Steel Company, Frick Building, Pittsburgh, Pa., has awarded a contract to the American Bridge Company, Pittsburgh, for the structural steel for the superstructure of its proposed new one-story plant at Wyckoff, near Ambridge, Pa. It will be 60x250 feet, and is estimated to cost approximately $75,000. It is proposed to have the structure ready for service early in the coming year.

The Southern Coal & Iron Corporation has acquired the plant and property of the Rittenhouse Iron Company, Rittenhouse Gap, near Mertztown, Pa., in the Lehigh iron district of the state. The new owner will place the works in immediate operation for the production of iron products to be used by various interests in this same section, including the Bethlehem Steel Company and the Eastern Steel Company, for blast furnace work. The properties are estimated to contain about 700,000 tons of proven iron ore and approximately 5,000,000 tons of potential iron ore, containing over 50 per cent iron and which will be concentrated at the plant to a 65 per cent iron basis.

The Beloit Iron Works, Beloit, Wis., has preliminary plans under way for the construction of an addition to its plant for increased production. The structure will be one-story, 65x85 feet, and is estimated to cost close to $55,000, including equipment. E. H. Neese is vice president of the company.

The Virginia Shipbuilding Company, Alexandria, Va., is reported to be planning for the immediate rebuilding of its steel fabricating plant, recently destroyed by fire with loss estimated at close to $125,000, including machinery. The plant is located on the Potomac River.

The General Iron Works Company, 1720 California Street, Denver, Colo., has preliminary plans under way for the construction of a new one-story building, to be located at Blake and Thirty-third streets. The structure will be supplemented by a number of smaller buildings. The new plant is estimated to cost about $100,000, including equipment. Bids for erection will be asked at an early date.



The Open Hearth

F. E. Stapleford was elected president of the Cincinnati Association of Purchasing Agents at the annual meeting on September 22. J. C. Kreis was elected vice president; G. C. Merkel, treasurer, and E. W. Simpkinson, secretary. The entire membership, numbering 80, attended the convention of the National Association at Indianapolis.

V V

Robert McKean, general manager Riter-Conley Company, Pittsburgh, returned recently, after an absence of two a half years in France, to this country. Mr. McKean had charge of the European interests of his own company and the McClintic-Marshall Co., an affiliated company.

V V

James A. Campbell, president of the Youngstown Sheet & Tube Company, is among those who have accepted invitations to participate in the unemployment conference which recently opened in Washington. Among the acceptances were those of John D. Ryan of the United Metals Selling Company; M. F. Tighe, president of the Amalgamated Association of Iron, Steel and Tin Workers, and John A. Penton, secretary American Pig Iron Association.

V V

A. J. Billimoria, Bombay, India, head of the firm of managing agents of the Tata Iron & Steel Company of the various other Tata interests, is now in New York on business with Perin & Marshall, consulting engineers. He returned to London in October and later will proceed to India.

V V

Richard Jones, Jr., is recovering from an operation which he recently underwent in the Youngstown City Hospital. Mr. Jones is general counsel for the Republic Iron & Steel Company, Youngstown, Ohio.

V V

H. W. Bishop, Jr., was recently made sales manager of the Superior Pipe Company, Columbia, Pa. Mr. Bishop was formerly in the general sales department of the La Belle Iron Works, Steubenville, Ohio.

V V

David P. Hopkins, general works manager of the United States Cast Iron Pipe & Foundry Co., Burlington, N. J., is traveling in Europe to investigate conditions in the European iron and steel business with special reference to the manufacture of cast iron pipe. Mr. Hopkins attended the joint meeting of the British Iron and Steel Institute and the Comite des Forge in Paris and Lorraine.

V V

Edward M. Huggins was recently promoted to the position of chief engineer of Sneed & Company, Jersey City, N. J. Mr. Huggins was formerly assistant chief engineer. He was graduated from Lehigh University in 1900 with the degree of mechanical engineer and has been with the Sneed Company since 1913. Prior to that he was with the E. H. Munford Company, maker of foundry molding machinery, for seven years, serving in various capacities, including that of chief engineer.

V V

Walter S. Tower, recently named as the first chief of the iron and steel industrial division of the Bureau of Foreign and Domestic Commerce, has been appointed commercial attache of the bureau at London and sailed October 7 from New York to take up his new duties. He succeeds Alfred P. Dennis as commercial attache, Mr. Dennis having been named to make an investigation of agricultural conditions in Europe. Mr. Tower has been succeeded as head of the iron and steel division by Luther Becker, Montclair, N. J., who now is serving as acting chief of the division.

V V

W. F. Abel, who for 13 years was in charge of sales for the Halcomb Steel Company, has been appointed assistant general manager of sales of the Electric Alloy Steel Company, Youngstown, Ohio.

V V

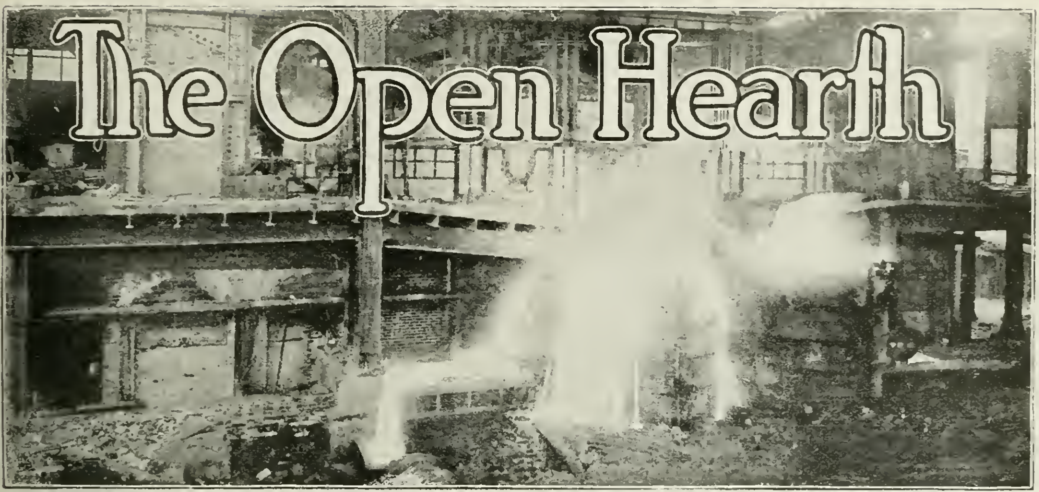
H. O. Davidson has severed his connection with the Hydraulic Steelcraft Company as general manager to become general manager in Baltimore of the C. D. Pruden plant of the Blaw-Knox Company, Pittsburgh.

V V

J. M. Ross, auditor of Wheeling Steel Corporation since its formation, recently was elected secretary of the corporation, succeeding G. W. Hocking, who resigned early in August. Prior to joining the Wheeling Steel Corporation, Mr. Ross was identified with Price, Waterhouse & Co., and gained considerable familiarity with the steel business through auditing the accounts of steel companies. He will act for the present as both secretary and auditor.

V V

Col. Henry P. Bope, New York, former first vice president of



the Carnegie Steel Company, Pittsburgh, of which company he also was general sales manager, has been elected a director of the International Sheet Tube Company, Cleveland. It is understood Col. Bope, in addition to being a director, will hold an executive position with the company, possibly president, although announcement to this effect has not been made. The International Sheet Tube Company has a tube plant under construction at Cleveland.

* * *

H. P. Parrock recently resigned as general manager of the Lumen Bearing Company's plants at Buffalo, N. Y., and Youngstown, Ohio, but remains on the Youngstown directorate. He will engage in professional work at present at 164 Lancaster Avenue, Buffalo, covering the design and construction, but more particularly the active operation of foundries, specializing in brass foundry work. His connection with the Lumen Bearing Company began in 1910, and he served at different times as sales manager, manager and general manager. For two years after graduating in 1901 from the Massachusetts Institute of Technology he served as assistant superintendent of the rolling department of the Pennsylvania Steel Company, and from 1904 to 1990 was superintendent of the steel foundry of the Youngstown Foundry & Machine Company.

* * *

E. E. Barto was recently appointed production manager of the Warren Iron & Steel Company, Warren, Ohio. Mr. Barto, for the past three years, has been connected with the Indiana Rolling Mill Co., Newcastle, Ind., in the capacity of production manager. Fifteen years previous to that, Mr. Barto was connected with the Jessop Steel Company, Washington, Pa., as rolling mill superintendent. He has had experience in rolling high carbon and alloy open-hearth, electric furnace, and crucible steels.

* * *

Henry B. Barnhart, 59, superintendent of the open hearth department of the Brier Hill Steel Company, Youngstown, Ohio, died on the evening of October 3 from paralysis. Mr. Barnhart had been identified with the Brier Hill Steel Company for the past five years, after resigning as department superintendent of the Illinois Steel Company, Chicago, where he had served for eight years.

* * *

J. L. Neely has been promoted to the position of traffic manager, in place of the late Andrew G. Young, of the American Sheet and Tin Plate Company. Mr. Neely was, for the past eight years, assistant traffic manager and has been connected iwth this department for the past twenty years.

* * *

John F. Miller of Pittsburgh, Pa., vice president of the Westinghouse Air Brake Company, Pittsburgh, has been elected an alumni trustee of the College of Wooster, Wooster, Ohio, filling an unexpired term in the class of 1922. Mr. Miller was graduated from the college in 1881.

* * *

William Whistler Mills, for five years assistant chief chemist of the Pittsburgh Crucible Steel Co., Pittsburgh, Pa., at its Midland, Pa., works, has been added to the faculty of the College of Wooster, Wooster, Ohio, as an instructor in chemistry. Mr. Mills resigned from the Pittsburgh Crucible Steel Company in 1919 to take up graduate work in Ohio State University, Columbus, Ohio, which he completed last June with the degree of Master of Science.

* * *

Frank R. Huston has been appointed general superintendent, in place of A. W. Courtney who has resigned, of the Donner Steel Company, Buffalo, N. Y. Mr. Huston was formerly chief auditor and has been with the company since its organization, going there from the Cambria Steel Company, Johnstown, Pa.

* * *

Edward Ray Weidlein, acting director of the Mellon Institute of Industrial Research, University of Pittsburgh, has been appointed director of the institute. Mr. Weidlein, who has been associate director since 1916, assumed the office of atcing director when Dr. Raymond Foss Bacon resigned some time ago to engage in chemical practice in New York. Mr. Weidlein was a student of the late Dr. Robert K. Duncan and later became an industrial bellow of the Mellon institute. He has been associated intimately with the industrial fellowship system since 1909, and since 1916 has been a member of the administrative staff of the Mellon institute. He has had experience in the supervision of industrial research and enjoys a national reputation as a specialist in the systematic investigation of the problems of chemical and physical technology. He was born at Augusta, Kan., July 14, 1867, and was graduated from the University of Kansas with the degree of bachelor of arts in 1909; in 1910 he received the degree of master of arts.

WITH THE EQUIPMENT MANUFACTURERS

A NEW LINE OF HOISTS.

Plant Superintendents will be interested in learning that the Treadwell Engineering Company, Easton, Pa., has placed a new line of hoists, both steam and electric driven, on the market. The Treadwell Engineering Company, while a long established and well known manufacturer of rolling mill equipment, has not, hitherto, been so closely identified with the mining field.

In entering upon the building of its line, the Company states that it has been fortunate in securing the services of Mr. Thos. O. Werner as chief engineer of its hoist department. Mr. Werner is widely known as a hoist expert, having been associated with the S. Flory Manufacturing Company in a similar capacity for many years.

The combination of sound design, and the patented features which are pointed out as distinct improvements, with the vast manufacturing facilities of the Treadwell Works should make the line one which will enjoy marked favor with users of such equipment, both for its mechanical excellence and for the service which the manufacturer is in a position to render.

Among the features which distinguish these new hoists is a double-toggle clutch mechanism which is claimed to be a step forward in design. The clutch is usually mechanically operated by a double acting cylinder, although it can be arranged for hand operation if desired. A point is made of the fact that the clutch (of the hand type) drives directly from the rim of the main gear, which carries the driving portion of the clutch, to the friction flange of the drum. This construction necessarily eliminates any torsional stress in the drum shaft, and end strain or thrust in the bearings or operating mechanism, for when brought into play this device is automatically locked.

Other points of structural excellence, of which mention may be included, are the tongue-and-grooved joints between all sections of the main frame to afford a rigid bolting together, the fact that the motor and intermediate bearings are mounted on a one-piece casting, the very satisfactory provision for lubrication at all bearings, and the entire absence of cast iron in the mechanism of the differential brake or brakes, with which these machines are provided.

The Treadwell Company is building a complete line and is prepared to offer a machine to meet practically any operating conditions within a range of from 100 to 300 horsepower. These hoists can be arranged for either electric motor or steam engine drive.

NEW SWITCH INTRODUCED.

A compact, light weight, quick acting contactor with blowouts and copper to copper rolling contacts is the outstanding feature of the new across-the-line type of starting switch just being placed on the market by the Allen-Bradley Company, Milwaukee, and described completely in a new bulletin J-1552 just issued. This starting switch is for use with small alternating current induction motors that can be connected directly to the supply lines. Automatic control of the motor is obtained when the starting switch is used with a push button, pressure gauge, flat switch, thermostat or any other type of pilot circuit control.

The principle of this switch is not new as the Allen-Bradley Co. has manufactured across-the-line switches for a number of years, but the design is new and distinctive in the simplicity of the assembly of the switch parts and cabinet. The copper to copper rolling contacts, blowouts and the laminated magnetic circuit are the same design as used on the larger quick-acting magnetic switches, but simplification of the assembly make this switch available for general use as a safety device with all automatic features where formerly the cost made it prohibitive when compared to manual switches.

Complete overload and low voltage protection are offered by the starter when used with standard push button. Failure of the supply voltage or a continuous overload will open the contactor, thus disconnecting the motor. Return of the voltage will not reconnect the motor unless the start button is pressed. Likewise the motor cannot be started after an overload unless the start button is pressed. When used with float switches, or pressure gauges, the starters are furnished with hand reset overload relays to prevent restarting of the motor after an overload has opened the circuit. With these auxiliary controls low voltage release is offered. Return of voltage to normal after temporary suspension will automatically re-connect the motor and insure continued performance from the pump, compressor or similar connecting equipment.

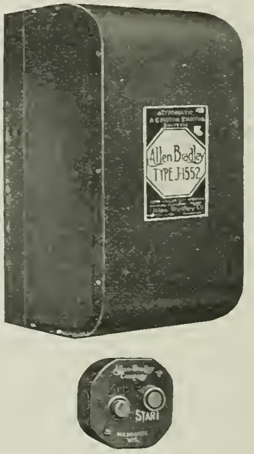


Fig. 1.

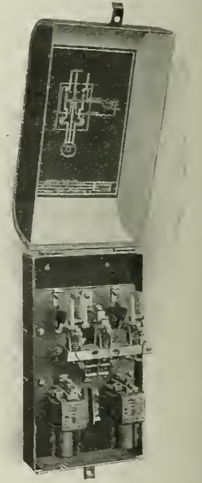


Fig. 2.

The use of magnetic blowouts, together with a light weight contactor which makes and breaks the circuit quickly, practically insures interruption of the circuit even under extreme conditions of overload.

The overload relays are of the inverse time limit dash pot type. They are the same as used for overload protection on all Allen-Bradley starting and current controlling devices and by other manufacturers as part of their standard starting equipment. The Allen-Bradley relays have a unique double seal of the piston in oil, which insures the full time element, yet there is little motion of the piston until the seal breaks, when the piston is released suddenly so that the relay contacts are tripped open quickly and positively.

Some Pointers on By-Product Coke Oven Operations

SOME INFORMATION ON THE PIETTE BY-PRODUCT OVEN.

This oven has been built for many years in several countries in Europe, particularly Belgium and France.

It is not a new oven, but an improved and in every respect modern oven, which has already stood a long test as to yields in coke, gas, by-products and durability in a manner never exceeded. Its very simplicity of construction makes it adaptable to the different conditions of the industries whatevery difficulty, and the several designs existing respond each one to a particular requirement of the industry or to a particular kind of coal. With some coals the problem of the designer of the oven is not only of which construction will permit their coking but which will do it economically when both first outlay and operation expenses are considered.

The several designs of Piette ovens built so far are the following:

Combined ovens of waste heat type capable of working without alteration, with or without recovery of by-products.

By-products recovery and waste heat ovens.

By-products ovens with regenerators.

By-products ovens with regenerators arranged for heating with coke oven gas or with heated blast-furnace or producer gas.

Inverted flame type of regenerative by-products coke ovens, with vertical heating flues, designed to make good coke out of certain kind of coals, high in volatile matters but lacking in coking properties.

The following is a description of the demonstration ovens which have been built at the Coke Station of the Laclede Gas Light Company at St. Louis, Missouri, in 1920 and are being operated by said company and are of the by-products type with regenerators.

Their dimensions are:

Height under arch:	9 ft. 10⅝ inches.
Length between doors:	37 ft.
Average width:	19¾ inches.

This oven is with vertical flues, with regenerators acting transversely and with reversing device. The gas and the air enter in all the flues situated on one side of the inversion axis of the battery, along the coke side for one period of ½ an hour and along the pusher side for the following half hour period. The burnt gases travel downwards through all the flues situated on the other side of the inversion axis.

On the top of each vertical heating flue a regulation section of which the size has been carefully but definitely arranged at the time of the construction, connects the flue with a horizontal chamber (t) above.

On each side of the coke oven wall the gas is sent through four tuyeres to conducts located at the foot and in the axis of the oven wall. These conducts lead to distribution chambers (a) and each room feeds the burners of one set of 3 or 4 heating flues.

Part of the combustion air circulates first in the galleries (g) and (h) where it is heated for the first time before entering the regenerators. The regenerating galleries extend over the whole length of the battery. Each regenerator is composed of 2 galleries located side by side which galleries communicate with each other through numerous openings. One of the galleries contain less checker brick work than its parent gallery, and the free space above said checker work constitutes the air entrance conduct in one period of inversion and the burnt gas collector in the following period.

The flow of the air through the checker brick work, as well as the flow of the burnt gases travels therefore parallel to the axis of the oven and it is only in the free space of the two regenerating galleries that the flow of the gaseous currents travels longitudinally.

The sole-flues (S) connect the regenerators with the foot of the oven-wall.

The connecting channels between the regenerators and the sole-flues are regulated by damper bricks (r).

Air nozzles connect the sole-flues with the heating flues of the ovens. Each part of the oven walls can be inspected through vertical flues existing in the top of the battery and which are closed by plugs.

A rapid control of the heating of each oven wall is facilitated by loopholes located on the front of the oven at the level of the horizontal room (h). Appropriated holes allow a quick inspection of the sole flues.

The color of the regenerators is easily watched through inspection holes situated at each end of the battery.

Results of 30 consecutive days' test of the Piette ovens built in St. Louis, Mo., at the plant of the Laclede Gas Light Company:

Mixture of coal charged:	
65 per cent Elkhorn.	
35 per cent Pocahontas.	
Average analysis of mixtures:	
Moisture	4.433%
On dry basis:	
Volatile Matter	30.416%
Ashes	5.378%
Fixed Carbon	64.208%
Coking time: 20 Hours, 18 Minutes.	
Load per oven: 26,770 Pounds.	
Total yield in Coke: 69.19 per cent. (Coal moisture included and dry coke.)	
Average analysis of coke:	
Moisture	1.936%
On dry basis:	
Ashes	6.900%
Fixed Carbon	92.110%
Volatile Matter	0.990%
Total gas produced:	
Per pound of coal charged	5.849 cu.ft.
Calorific value of this gas	564.5 Btu.
Yields in By-Products, per Ton of Coal Carbonized:	
Ammonia, in pounds	5.632
Tar, in gallons	7.009
Benzol (product distilling below 200 Centigrade in gallons)	3.416
Calorific Balance of a Piette Ovens Battery—Demonstrated in the St. Louis Test:	
Btu produced	100 per cent.
Btu in the surplus gas	63.25 per cent.
Btu consumed in the heating gas	36.75 per cent.

TRADE NOTES

Mr. Abner U. Howard has been appointed Sales Manager for N. & G. Taylor Company, Inc., General Offices, 300 Chestnut Street, Philadelphia. Mr. Howard was for many years connected with the National Conduit & Cable Company of New York City and recently with the Stamford Rolling Mill Company of Stamford, Conn., as Sales Manager.

The Blaw-Knox Company wishes to announce the addition to its staff of Mr. H. O. Davidson. Mr. Davidson will have entire charge of the Prudential Sectional Building Department of the Blaw-Knox Company and will be also General Manager of the C. D. Pruden plant of the Blaw-Knox Company. Mr. Davidson will be located at the C. D. Pruden plant at Baltimore. Mr. Davidson was connected for eight years with the Hydraulic Steelcraft Company, being General Manager of that organization at the time he severed his connections to become a member of the Blaw-Knox staff.

The Denk Engineering Company has been incorporated to do business in designing and installing gas plants, furnaces and piping. The offices of the company are in the Shannon Building, 4th Avenue, Pittsburgh, Pa. F. J. Denk is president and consulting engineer.

The Ford Motor Co. have recently placed an order with the Electric Furnace Construction Co., 908 Chestnut Street, Philadelphia, for two large "Greaves-Etchells" Electric Furnaces for their new plant at the Rouge Works, Dearborn, Michigan. The furnaces will be basic lined, and they are designed to operate either for melting up accumulation of scrap or for treating hot metal. This is the third order placed for this type of furnace by the Ford Company, the first unit having been installed at the Highland Park Works in 1917.

Northern Engineering Works report the sale of a 20-ton, 3-motor electric travelling crane to C. W. Marthens Co., Chicago.

Chain Belt Company, Milwaukee, Wisconsin has opened offices at 735 Ellicott Square, Buffalo, N. Y., and have announced the appointment of T. E. Cocker as District Manager of that territory. Mr. Cocker will handle the REX Line including Chain, Sprocket Wheels, REX Traveling Water Screns, Elevators and Conveyors.

TRADE PUBLICATIONS

The Northern Engineering Works have issued a new booklet entitled, "Northern Cranes In The Foundry." It covers this subject very completely.

Bulletin No. 234—"The Continuous Heat-Treatment of Metals With Automatic and Semi-Antomatic Furnaces," has been issued by the W. S. Rockwell Company. This is the fourth of a series dealing with fundamentals that influence quality and cost of heated products. It illustrates practical applications of the principles outlined by the previous bulletins of the series.

A. C. Automatic Starters with Mercury Type Overload Relays, is the subject of a new publication (2038) describing and illustrating this new type of starter designated as Bulletin 9604, made by the Cutler-Hammer Mfg. Co., of Milwaukee. The theory of the new mercury interlock is given and curve included to show how tripping depends upon the time and the percentage of overloading.

Heat Resisting Alloys—The General Alloys Company, New York, has compiled a 28-page booklet describing Q-Alloys. An important feature of this book is the description of their new heat resisting alloy which is sold at 20c per pound.

R. D. Nuttal Company, Pittsburgh, Pa., recently published a 4-page folder entitled "Drop Forged Steel Pinion Blanks," which describes the method of forging and upsetting pinion blanks. This folder gives the results of tests on these forgings and is illustrated with macrophotographs showing the grain structure.

The Box Bulletin—Published by the General Alloys Company, New York, contains several short articles which should be of interest to our readers. The first article is the "Selection of a Carbonizing Compound," by H. B. Knowlton, and the second "The Design of Carbonizing Containers," by George Charlton.

Air Hammers—The Nazel air hammer is very completely described in the recent booklet published by the Nazel Engineering & Machine Works, Philadelphia, Pa. In it the operating principle is discussed. The general construction, motive power and the various types of hammers are taken up in detail.

Furnace Screens — Weigand patented chain furnace screens for furnaces and ovens are described in a small 8-page booklet recently issued by the E. J. Codd Company, Baltimore, Md.

The Selas Company, Philadelphia, Pa., in a 4-page circular discuss economical gas utilization and the adjustments on the Selas machine for securing complete combustion.

Rezistal Steel—In a booklet recently issued by the Crucible Steel Company of America, C. M. Johnson, director of the Research Department, describes this new steel which is non-magnetic and resists the action of flame, acids and rust. It includes a paper which was presented before several chapters of the American Society for Steel Treating and a number of testimonials from users of this new steel.

The Titanium Alloy Manufacturing Company, Niagara Falls, N. Y., in a leaflet offers the facilities of the Commercial Service Department of the physical, metallurgical and metallographic laboratories to manufacturers and others interested in metallurgical and mechanical lines.

The Robbins Conveying Belt Co. have recently published a Hankbook of Conveyor Practice which should prove valuable to engineers and draftsmen having to do with the planning or designing of conveyor installations for whose aid it is intended. Besides describing and illustrating installations of various kinds erected by the above company, the book contains a group of tables governing capacities, power requirements, speeds of conveyors, and similar matter, together with general data on conveyor practice. 96 pages, size 6 x 9, bound in heavy cover.

A bulletin known as their No. 9 Catalog, entitled Pulverized Fuels has just been published by the Hardinge Co., New York, N. Y. The bulletin is divided into three main sections covering, respectively, the application of pulverized fuel as a solution of various combustion problems, the principle of operation of the Hardinge mill, and a discussion of the Hardinge system for pulverizing fuels. The catalog contains in addition to the descriptive matter, many interesting illustrations. Size 8½ x 11, sixteen pages and cover.

Concrete Bins and Pits for Coal Storage is the title of an interesting pamphlet published by the Portland Cement Association. It contains information and illustrations showing why and how coal should be stored. 16 pages, size 6 x 9.

Bulletin No. 232, The Variety of Furnace Design is the third of the series dealing with the fundamentals that influence the quality and cost of heated products, issued by the W. S. Rockwell Co., New York, N. Y. This bulletin illustrates the relation of type and arrangement of heating equipment to cost of production, and the many factors that must be considered in adapting such equipment to individual manufacturing conditions.

The George J. Hagan Co., Pittsburgh, Pa., have issued another of their series of bulletins on various types of industrial furnaces. This one which is entitled Standardized Heat Treating Furnaces, Combustion Type covers a line of standardized furnaces burning oil or gas, for steel hardening, carbonizing, annealing, and similar heat treating operations.

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FOR THE MANUFACTURING OF
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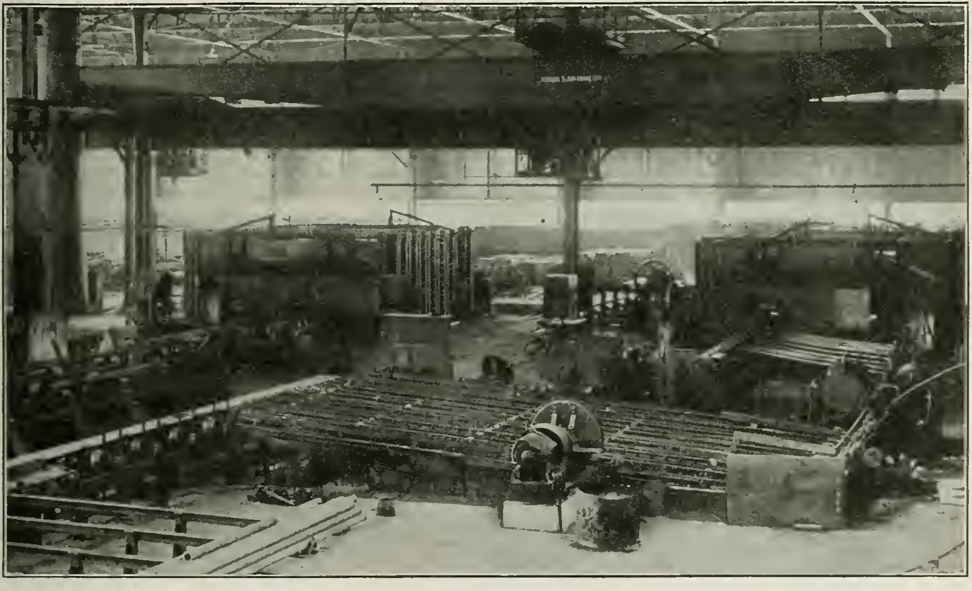

The above illustration shows two up-to-date Butt Weld Tube Mills for ½″ to 3″ diameter pipe. Each mill can produce 9,000 tubes ½″ dia. x 20′0″ long in 10 hours. Our Lap Weld Mills for 2″ to 24″ diameter pipe are equally efficient.

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THE siren scream on city street or the pound of hammer on the rural engine tire—both shout the same warning to all building owners "*Look out for flying embers on your roof*" for every roof within earshot is in immediate danger—and even those that are well out of hearing are still within the fire circle once a fanned ember gets into the upper air currents. Jumps of one, two and even three miles are given in the fire records. So that the roof-communicated fire does not depend on the adjoining property for fodder. In the Atlanta Conflagration three widely separated fire centers were noted shortly after the initial blaze—roof-communicated all; and $5,500,000 was the charge that the National Board of Fire Underwriters made against the inflammable roof in this one fire.

Thus the urge for fire-safe roofing is a very real one because every house is all roof to the fire-brand—make the roof all-mineral—with Johns-Manville Asbestos—and this big cause of conflagrations is killed right there

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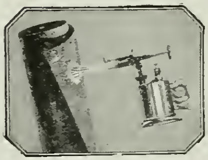
Johns-Manville Asbestos Roofings are approved by the Underwriters' Laboratories Inc., and take base rate of insurance.



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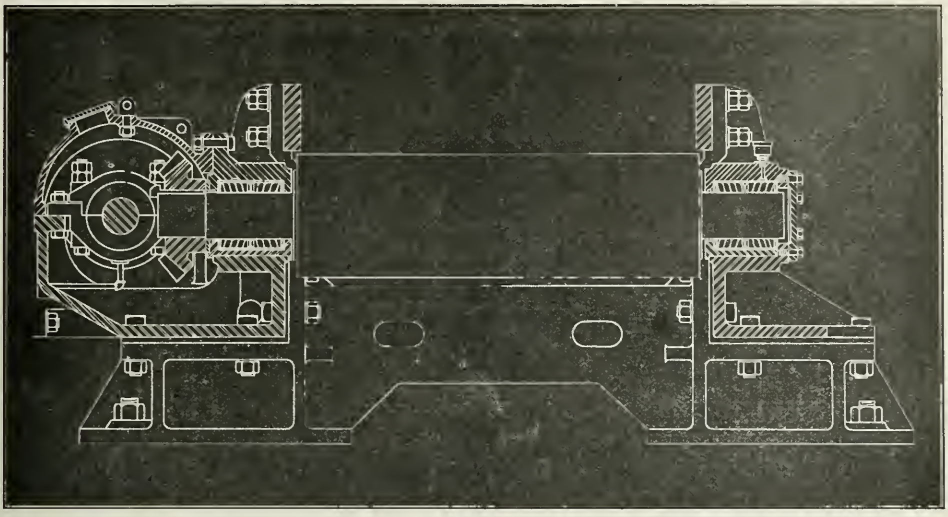

Good Practice! Blooming Mill Tables Equipped With Hyatt Roller Bearings

This is the design of a Hyatt equipped, 44″ blooming mill approach table that is in successful operation in a large Eastern steel mill.

In planning this table the designers endeavored to make it the most modern, most economical and dependable blooming mill table that could be built, based on sound principles of steel mill engineering

Naturally, such time tried improvements as cut steel gears enclosed in oil tight cast gear guards, and Hyatt roller bearings, were made an integral part of the new table. They are proving their worth on this mill and on the other 30 or more Hyatt equipped mills in representative steel plants in this country and abroad.

It is good practice, sound engineering, to use Hyatt roller bearings in mill tables of all kinds and the resulting dependability of operation and reduced maintenance costs assist materially in the production of steel at the minimum cost per ton.

In planning new steel mill equipment of any nature you cannot afford to overlook the many proven advantages of Hyatt roller bearings. Get in touch with one of our engineers in Chicago, Pittsburgh or Philadelphia.

Hyatt Roller Bearing Company, New York, N. Y.

Bearing Balls
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The man who knows realizes what an enormous saving of friction and wear they represent. He must recognize the mechanical genius which has wrought these steel spheres, in which a microscopic difference in diameter means rejection. He cannot help but admire the surface, which outshines the best of mirrors.

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To the man who does not regard Bearing Lubrication as a side issue, we address this message:

Texaco Bearing Lubricants are Second to None

Witness the fact that PRACTICALLY ALL of the manufacturers of Ball Bearings—and many manufacturers of units using them—recommend the use of Texaco Lubricants.

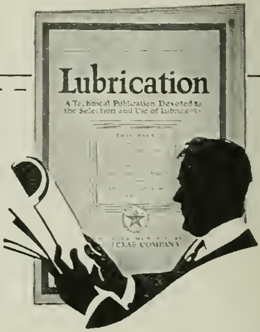
Texaco Bearing Lubricants include a full line of carefully made Texaco Greases and a selection of Texaco Bearing Oils for those which are designed to retain oil. Texaco Greases and Texaco Oils will take care of every known requirement.

Tell us what kind of bearings are installed in your equipment and we will tell you what kind of grease or what brand of Texaco Oil to use in them.

Of course we can at the same time tell you what kind and type of lubricant to use on any machine, motor, generator or prime mover.

There is a Texaco Lubricant for Every Purpose

To the man who wants to keep posted on the latest developments in the Science of Lubrication, we offer a free subscription to our monthly magazine, "Lubrication."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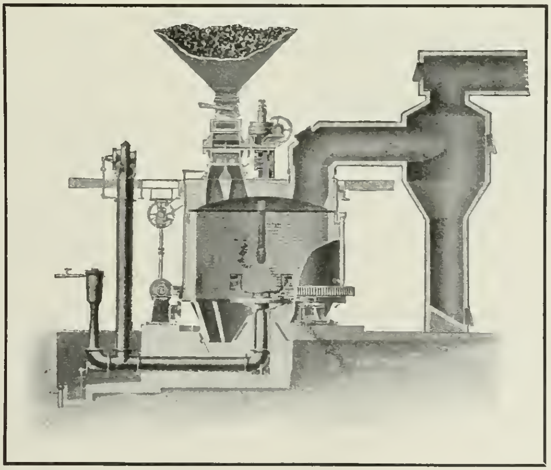

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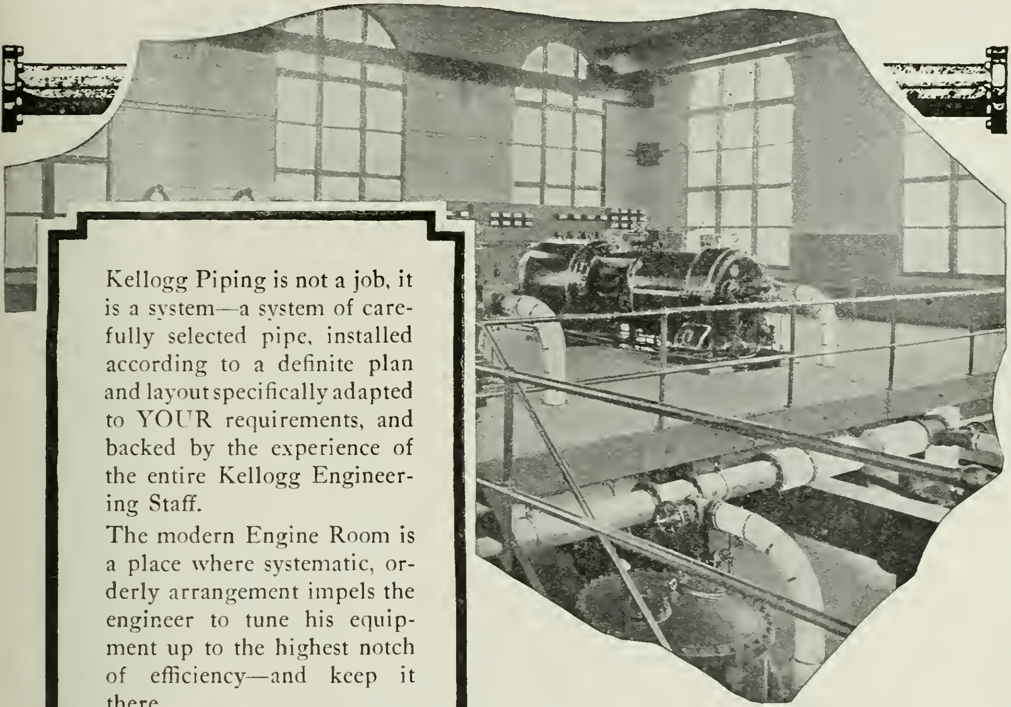
Allan Red Metal *and* Allan Bearing Bronze

KELLOGG POWER PIPING — MAKES FOR IDEAL ENGINE ROOMS



Kellogg Piping is not a job, it is a system—a system of carefully selected pipe, installed according to a definite plan and layout specifically adapted to YOUR requirements, and backed by the experience of the entire Kellogg Engineering Staff.

The modern Engine Room is a place where systematic, orderly arrangement impels the engineer to tune his equipment up to the highest notch of efficiency—and keep it there.

It is an Engine Room the Chief is proud of.

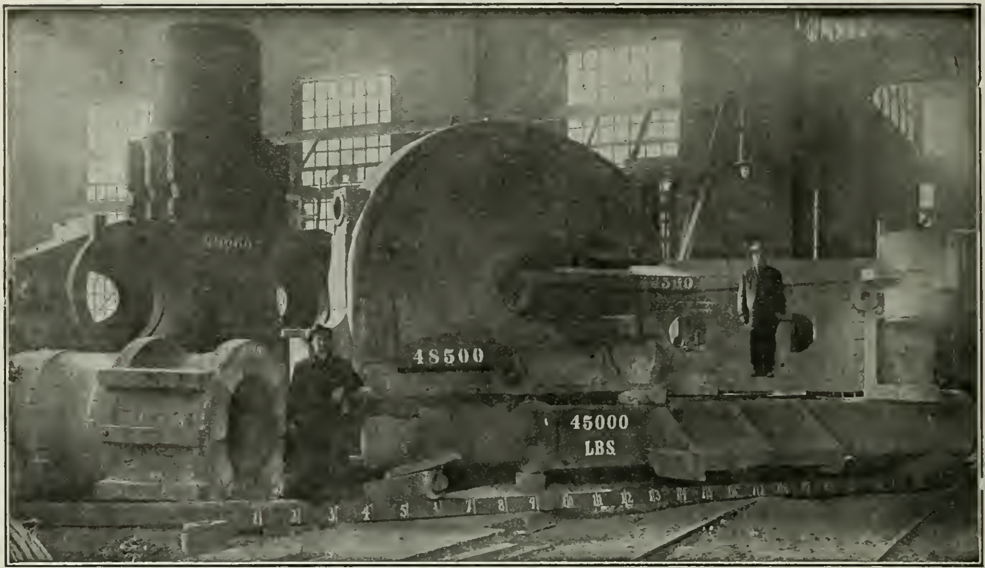
Kellogg Piping in the Power Plant makes satisfied engineers and efficient operation.

Ask for your copy of the Power Piping Reference Book

The M. W. Kellogg Co.
90 West Street, New York City

"See that it's Kellogg Built"

The M. W. Kellogg Co.
NEW YORK



BIRDSBORO
STEEL CASTINGS
IRON CASTINGS--INGOT MOLDS

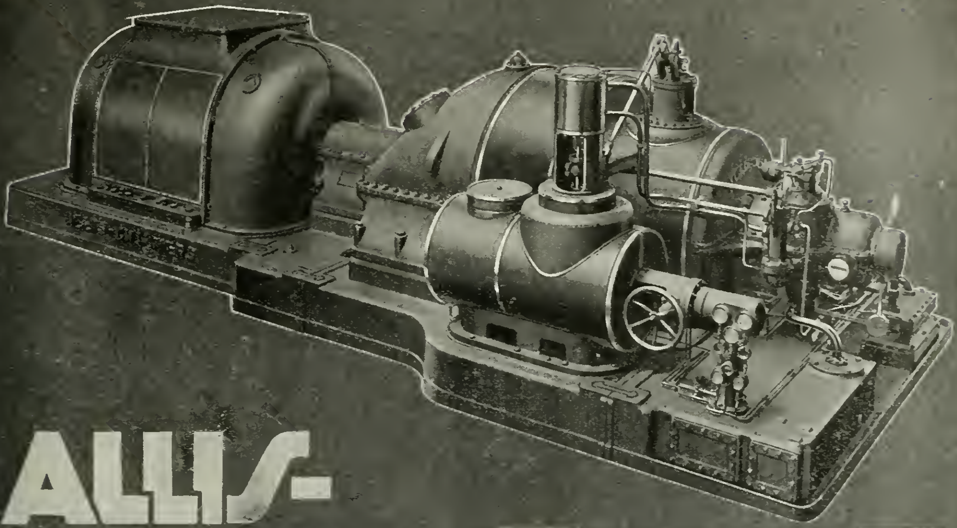
Iron Chilled and Sand --ROLLS-- Alloy and Carbon Steel
Durite (patented)

Blast Furnace Machinery, Rolls, Rolling Mill Machinery, General or Special Machinery, Buchanan Crushers and Concentrating Machinery, Chilled Iron Pump Plungers, Roll Lathes, Jackson Belt Lacing Machines.

Hydraulic Presses and Accumulators

Birdsboro Steel Foundry & Machine Co.,
Birdsboro, Pennsylvania

New York Office, 90 West St., New York City, Room 1710. Tel. Rector 6664-5-6.



ALLIS-CHALMERS

Steam Turbine And Alternator Units

The Allis-Chalmers' Steam Turbine has earned an enviable reputation for efficiency and reliability, and the fact that a large proportion of its output is for customers already using its equipment indicates the operator's confidence in the apparatus.

The turbine is of the straight reaction type, embodying improvements made by the Company's engineers from fifteen years experience in the manufacture and operation of steam turbines, and a complete line of standard units ranging in size from 200 K.W. to 12,500 K.W. has been developed to meet the most exacting conditions of service.

Allis-Chalmers Mfg. Co.

Milwaukee, Wisconsin

THE IRONSIDES COMPANY
COLUMBUS OHIO

TRADE MARKS REGISTERED
IRON SIDES

Ironsides Gear Shield

Ironsides Wire Rope Shield

Ironsides Automobile Gear Shield

Metal Costs More Than Lubricants—It's cheaper to preserve your wire ropes and gears with Ironsides lubricants than to replace them frequently.

Ironsides Wire Rope Shield—for preservation and lubrication—widely used in Mines, Blast Furnaces, Steel Plants and Factories.

Ironsides Gear Shield—lessens noise, wear and costly replacements—used by up-to-date Rolling Mills.

Ironsides Cold Neck Shield—the best roll-neck lubricant in existence—for Rolling Mills.

Ironsides Cold Neck Shield

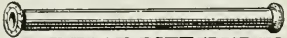
Service Plus Satisfaction

are incorporated into every Pittsburgh Piping installation. Pipe Bends used in place of elbows, provide for expansion and contraction, reduce friction and minimize loss of pressure.

Our machine shop, bending, forging and welding departments and our iron and steel foundries are equipped with the most modern tools and appliances.

Specify "Pittsburgh Piping" and you mention the best there is in Power Plant Piping construction.

"WHEN YOU
THINK OF PIPING

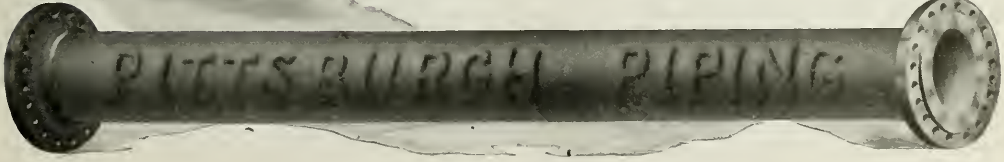


THINK OF PITTSBURGH
PIPING"

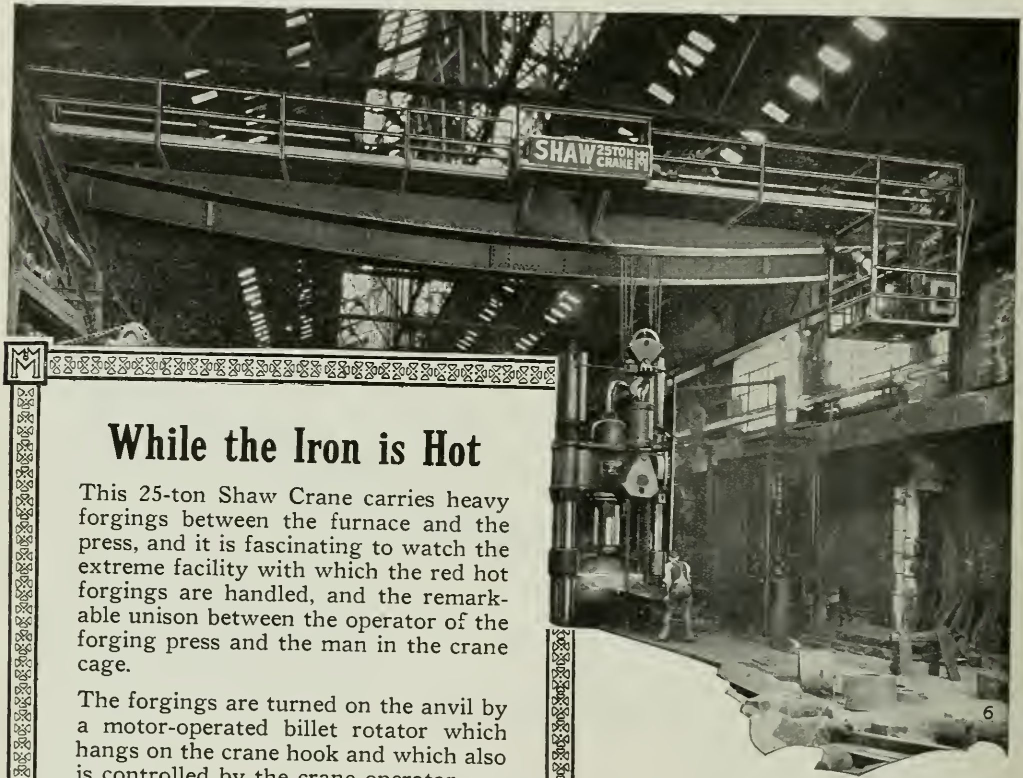
PITTSBURGH PIPING & EQUIPMENT CO.

MANUFACTURERS & CONTRACTORS
PITTSBURGH, PA.

NEW YORK 220 BROADWAY	CHICAGO PEOPLES GAS BLDG.	SAN FRANCISCO MONADNOCK BLDG.
CLEVELAND AMERICAN TRUST BLDG.	INDIANAPOLIS TRACTION TERMINAL BLDG.	BIRMINGHAM AMERICAN TRUST BLDG.



A SHAW CRANE



While the Iron is Hot

This 25-ton Shaw Crane carries heavy forgings between the furnace and the press, and it is fascinating to watch the extreme facility with which the red hot forgings are handled, and the remarkable unison between the operator of the forging press and the man in the crane cage.

The forgings are turned on the anvil by a motor-operated billet rotator which hangs on the crane hook and which also is controlled by the crane operator.

Forging service requires a sturdy crane to stand up successfully under the stress and shocks from the hammer or press and the control of all motions must be steady and accurate.

We would like to tell you more about our Shaw Cranes for forging service and special applications of similar character.

SC-7

When you buy an Electric Traveling Crane there are two main considerations—the crane must not only be built right, but must also be rightly applied to your conditions.
This is really a Contracting-Engineering business—every crane an individual project—and we have an Engineering Service backed by the accumulated experience of thirty years in the applications of our Shaw Cranes to all sorts of industrial purposes.

MANNING, MAXWELL & MOORE INC.

SHAW CRANE WORKS

119 WEST 40TH STREET, NEW YORK, N.Y.

DISTRICT SALES OFFICES. Chicago, Philadelphia, Boston, St. Louis, Pittsburgh, Cleveland, New Haven, Cincinnati, Buffalo, Syracuse, Detroit, Milwaukee, San Francisco, Seattle

CRANES · MACHINE TOOLS · SUPPLIES · VALVES · INJECTORS · INSPIRATORS · SAFETY VALVES · GAUGES

TRADE MARK
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CONFIDENCE

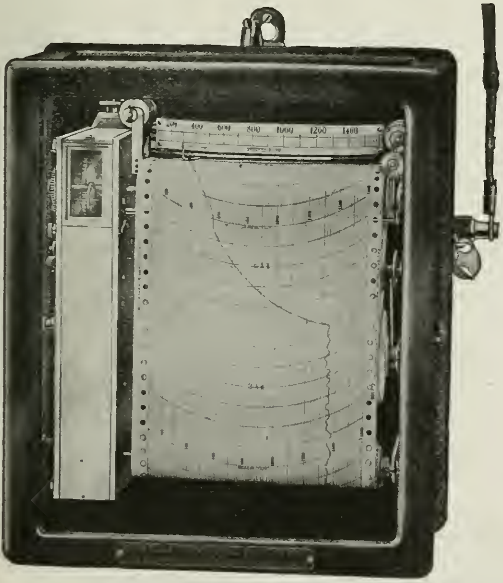
Fifteen years and more is not an unusual length of service for a Bristol's Recording Instrument. In many industrial plants there may be found recorders which have been in constant use for this length of time. We are proud of these "old recorders" —they stand for just the sincerity and reliability we have endeavored to put into them.

Time and Service Tested

BRISTOL'S

Recording Instruments

have earned the confidence which could not be gained otherwise. They have proved beyond any doubt that the performance in service is all and more than we claim.



The ever-growing demand for recording instruments is shown by the fact that a little over thirty years ago the only recording instrument was the pressure gauge, while now our line includes: Recording Instruments for Pressure, Vacuum, Temperature, Electricity, Time, Motion, Speed, Humidity, etc.

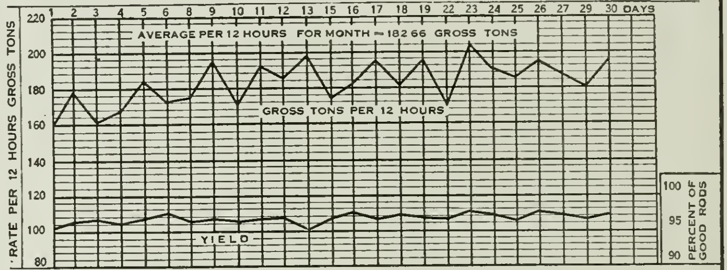
Get copy of Information Bulletin AD 303 telling about this line of recorders.

The Bristol Company
Waterbury, Conn.

MORGAN
OF WORCESTER
CONTINUOUS DOUBLE STRAND ROD MILLS

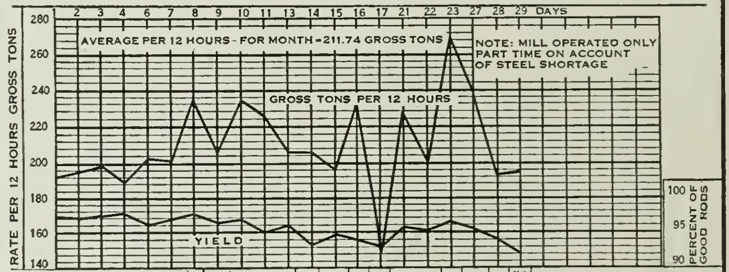
M C Co

MONTHLY RECORD APRIL 1918
PRODUCTION ON No. 5 RODS



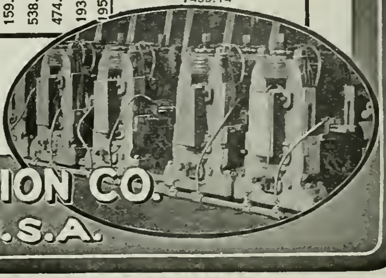
DAYS	SIZE OF ROD	HOURS	GROSS TONS
1	5	24	325.87
2	5	24	354.45
3	5	24	327.65
4	5	24	334.81
5	5	24	369.62
6	5	10	144.63
8	5	24	349.98
9	5	24	389.27
10	5	24	341.95
11	5	24	383.02
12	5	24	372.29
13	5	6	99.11
15	5	24	346.41
16	5	24	360.70
17	5	24	385.70
18	5	24	363.37
19	5	24	391.05
22	5	24	337.48
23	5	24	407.12
24	5	24	379.44
25	5	24	374.08
26	5	24	387.47
27	5	10	156.24
29	5	24	361.59
30	5	24	390.17
		554 46.17 SINGLE TURNS	TOTAL GROSS TONS 8433.47

MONTHLY RECORD MAY 1918
PRODUCTION ON MISCELLANEOUS ROD SIZES



DAYS	SIZE OF ROD	HOURS	GROSS TONS
1	5	24	384.81
2	5	24	388.38
3	5	24	391.05
4	5	10	155.35
6	3	24	407.12
7	3	24	406.22
8	3	24	466.93
9	3 2	24	409.80
10	2	24	466.05
11	2	7	133.03
13	0	24	410.68
14	0 .312	24	411.58
15	.306 .312 00	24	392.83
16	00 .343	24	462.48
17	00 1	12	150.88
21	1	24	454.43
22	1	9¼	159.81
23	.393 .406	24	538.36
27	.406 .378 .363	24	474.08
28	.363 .430	12	193.74
29	.462 .466	12	195.53
		422¼ 35.20 SINGLE TURNS	TOTAL GROSS TONS 7453.14

Pittsburgh Office
704 Arrott Bldg. Telephone Court 1381

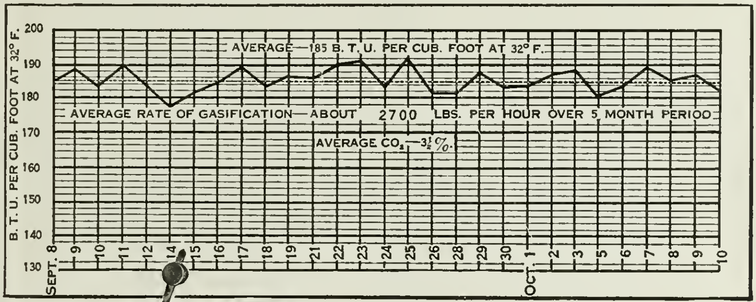


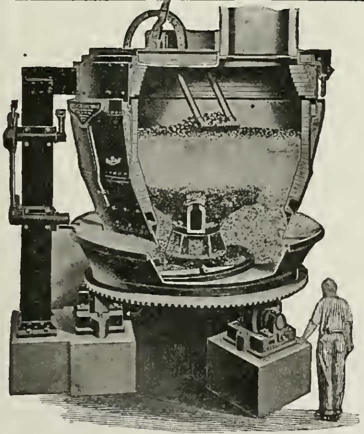
MORGAN CONSTRUCTION CO.
WORCESTER, MASS., U.S.A.

MORGAN
OF WORCESTER
PRODUCER GAS MACHINE

M C Co

Eight-hour Continuous Gas Samples from records of work's chemist at one of the well known Steel Plants in the U.S.A.





MORGAN PRODUCER GAS MACHINES maintain the quality of gas continuously at a high value - - - the operation is not dependent upon the human element.

Continuous Mechanical Feeding, Levelling and Ash Discharge

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WORCESTER, MASS., U.S.A.

MORGAN

ROLLER STRAIGHTENERS

FOR MERCHANT AND STRUCTURAL MILLS

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TIME SAVING

All rolls can be changed in
· 20 minutes ·

CONVENIENCE

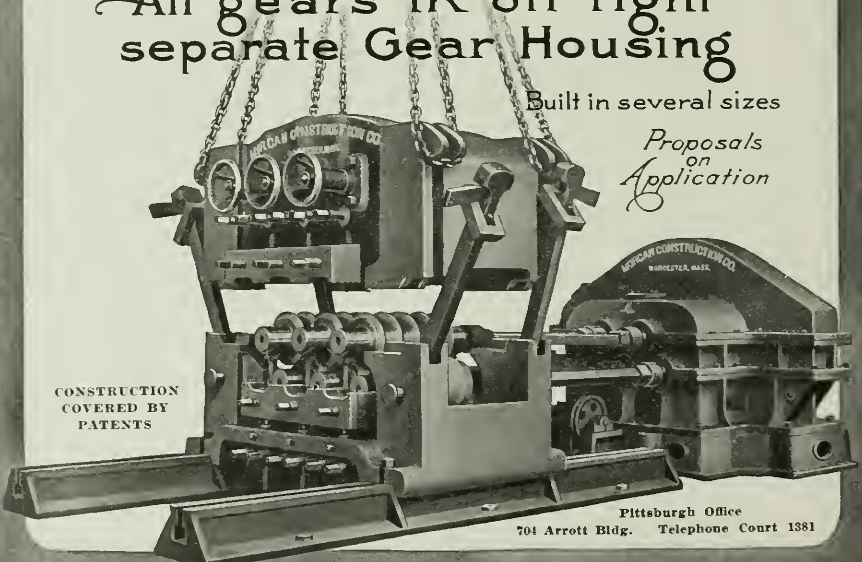
All roll adjustments from
· the front ·

CONSTRUCTION

All gears in oil tight
separate Gear Housing

Built in several sizes

Proposals
on
Application



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ADAMITE

Where There is Adamite
There is Efficiency

Our Rolls and Castings
will decrease your
Operating Expenses

PITTSBURGH IRON & STEEL FOUNDRIES CO.

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UNITED ENGINEERING & FOUNDRY CO.
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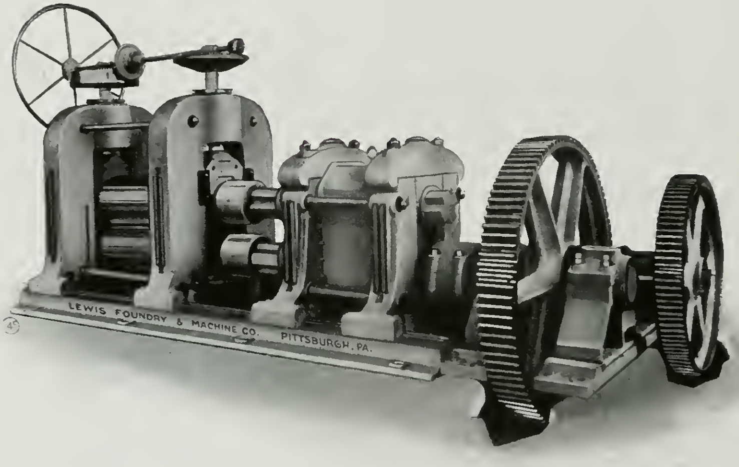
Adamite
is always
best in the
long run

The Best
Operators
are using
Adamite

ADAMITE

LEWIS FOUNDRY AND MACHINE CO.

FARMERS BANK BUILDING
PITTSBURGH, U. S. A.

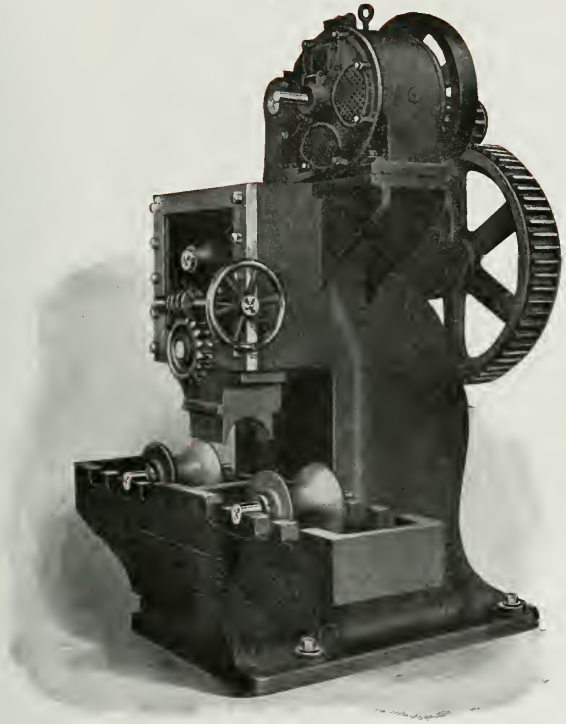


20" Breakdown Mill for Steel, Wire Cloth or Non-Ferrous Metals

BY INVITATION
MEMBER OF

NEW YORK, U.S.A.

PIPE STRAIGHTENERS



Will straighten pipe
2" diameter to
12" diameter

USED
Lap Welded
Seamless Tube
Reclaiming old Pipe

A. Garrison Foundry Co.

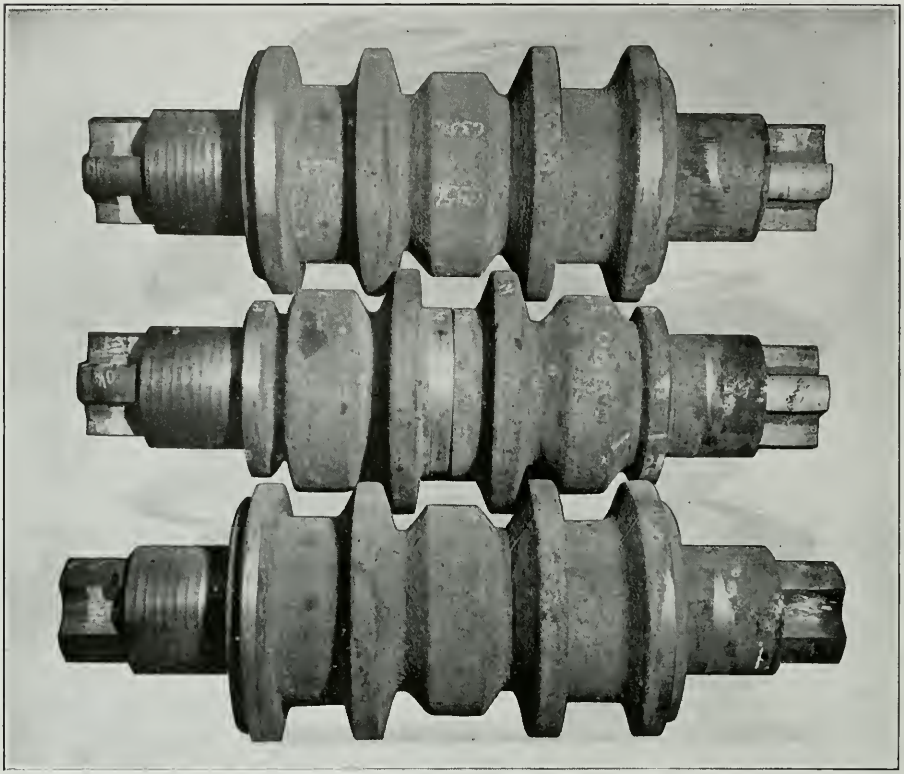
Pittsburgh, Penna.

Builders of

**Complete Machinery Equipment for Iron, Steel, Tube, Zinc,
Brass and Aluminum Works—Forging Presses
Sand and Chilled Rolls**

Write us for further information

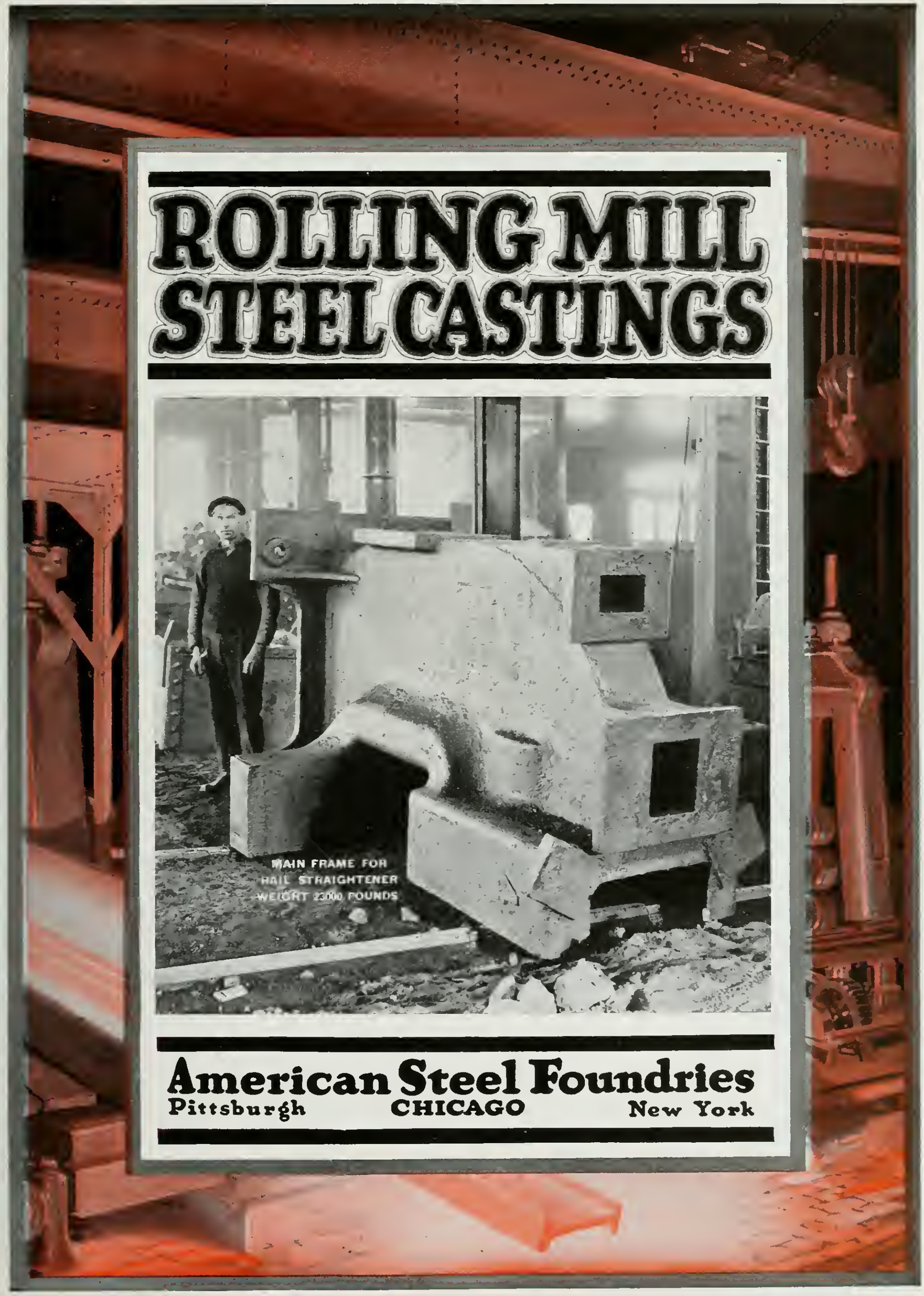
"WHEELING QUALITY"



STEEL ROLLS CHILLED ROLLS
SUPER-STEEL ROLLS SAND ROLLS

Steel Castings
Iron Castings
Special Machinery
Rolling Mill Machinery

Wheeling Mold & Foundry Company
WHEELING, W. VA.



ROLLING MILL
STEEL CASTINGS

American Steel Foundries
Pittsburgh CHICAGO New York

NATIONAL

Chilled Sheet and Tin Plate Rolls

FOR HIGH GRADE PRODUCTS

Why Experiment

Use the Best

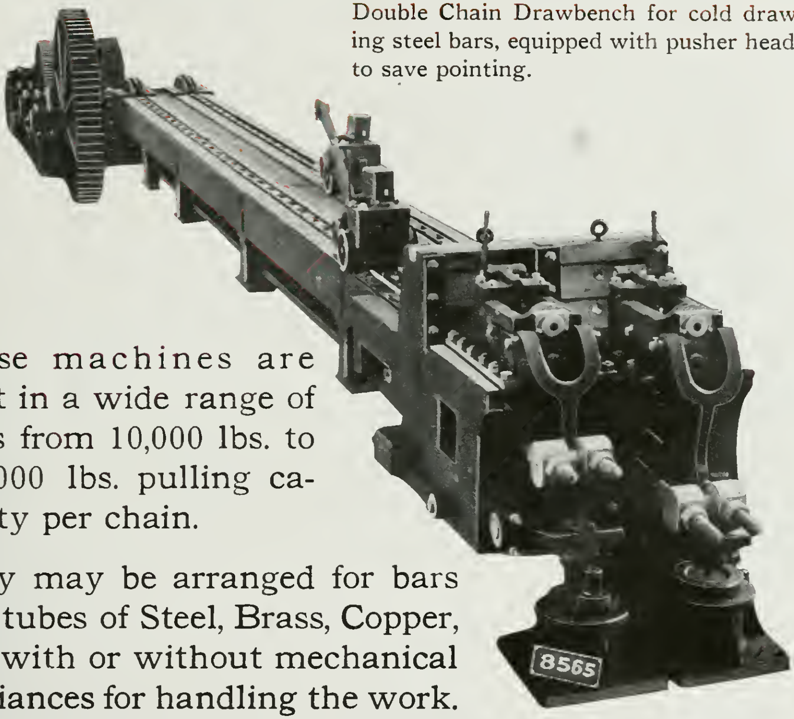
Rolling Mill Machinery Comprising

WEIGHT—RIGIDITY—WORKMANSHIP

NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PA.

STANDARD



Double Chain Drawbench for cold drawing steel bars, equipped with pusher heads to save pointing.

These machines are built in a wide range of sizes from 10,000 lbs. to 150,000 lbs. pulling capacity per chain.

They may be arranged for bars and tubes of Steel, Brass, Copper, etc., with or without mechanical appliances for handling the work.

Send for descriptive Literature.

We Design and Build
ROLLING MILL, PIPE MILL AND SEAMLESS TUBE MILL MACHINERY

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ENGINEERS and MANUFACTURERS
Ellwood City, Pa., U. S. A.

500 GRANITE BUILDING PITTSBURGH, PA.

CARBON STEEL

"OTISCO"
(Alloy)

OTIS ROLLS

Made to suit Mill Conditions. Otis Rolls are being used in some of the largest Plants in the Country, and have won favor in these Plants by their toughness, hardness, great strength and long service. What they are doing in other Plants they can do in yours.

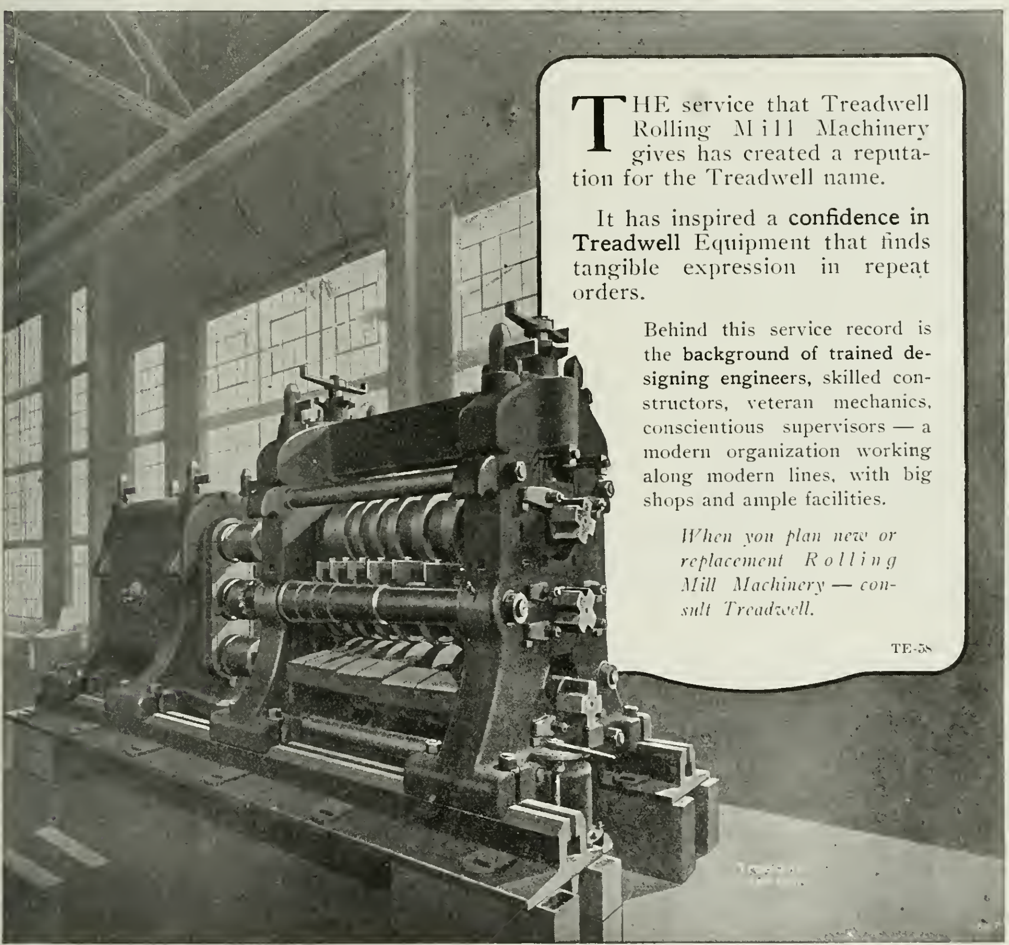
TRY THEM. THEY WILL REDUCE YOUR ROLL COSTS.

Prompt Deliveries

The Otis Steel Company, Cleveland, Ohio

Treadwell

Steel Mill Equipment



THE service that Treadwell Rolling Mill Machinery gives has created a reputation for the Treadwell name.

It has inspired a **confidence in Treadwell** Equipment that finds tangible expression in repeat orders.

Behind this service record is the **background of trained designing engineers**, skilled constructors, veteran mechanics, conscientious supervisors — a modern organization working along modern lines, with big shops and ample facilities.

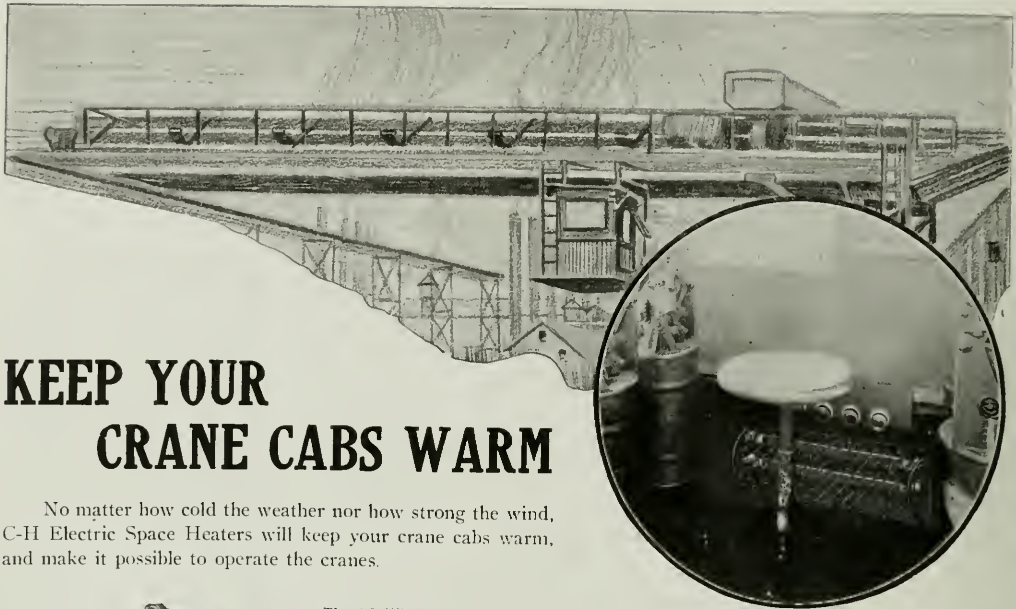
When you plan new or replacement Rolling Mill Machinery — consult Treadwell.

TE-58

Treadwell Engineering Company

ROLLING MILL MACHINERY — PIPE MACHINES — ELECTRIC STEEL CASTINGS

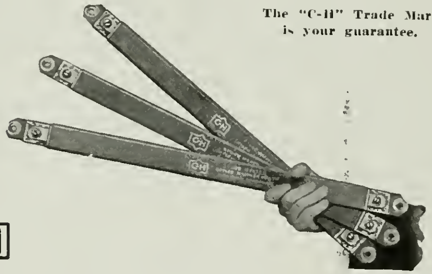
Easton, Pennsylvania, U.S.A.



C-H Space Heaters take up no room and are safe.

KEEP YOUR CRANE CABS WARM

No matter how cold the weather nor how strong the wind, C-H Electric Space Heaters will keep your crane cabs warm, and make it possible to operate the cranes.



The "C-H" Trade Mark is your guarantee.

C-H

ELECTRIC SPACE HEATERS

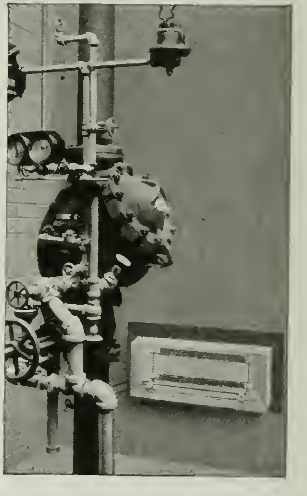
"Two Feet of Electrical Heat"

take up but little space—steel mill men have seen thousands in use in crane cabs, watchman houses, on platforms, exposed offices, etc., etc.

Mounted below perforated plates they are ideal for keeping shearmen and tablemen warm. In fact there are so many applications that one steel plant put in 2,000

The cold weather is with us for another four months—order from your supply house now.

THE CUTLER-HAMMER MFG. CO.
Works: Milwaukee and New York.



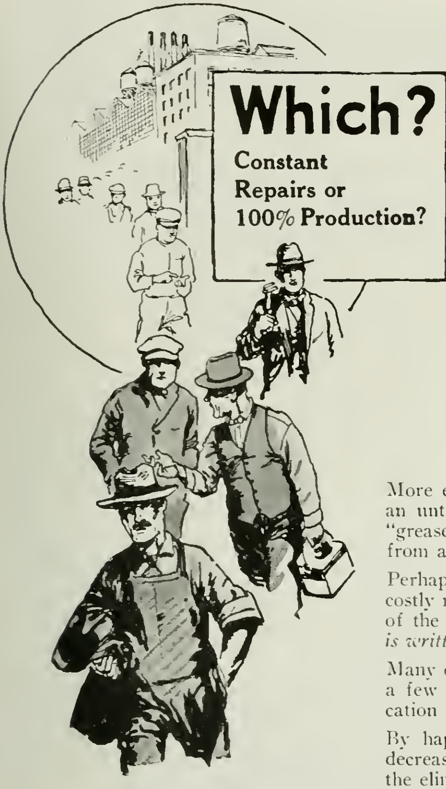
Riser and Valve Houses on Sprinkler Systems are protected when heated by C-H Electric Space Heaters. Nichrome resistor is used and Armco iron sheath. Both mounting eyelets are thoroughly insulated.

NEW BOOKLET

Send for a copy of the new "Dictionary of Uses" describing 125 proven applications. Other useful data on heating included.

CUTLER - HAMMER

THE DOMINANT CONSERVATION FACTOR


Which?
Constant Repairs or 100% Production?

KEYSTONE Lubricants End Costly Shut-Downs

More expensive shut-downs occur—more valuable machinery goes to an untimely grave in the scrap pile because some men think that "grease is grease"—that one kind is just as good as another—than from any other cause.

Perhaps you consider these frequent processions to the scrap pile, costly repairs, shut-downs and slowing up of production all as a "part of the day's work"—things that can't be helped. *If so, this message is written especially for you.*

Many of our most enthusiastic boosters today are those men who but a few years ago were absolutely certain that their methods of lubrication could not be improved.

By happy experience, by an increased volume of production with decreased operating expense, longer life for valuable machinery and the elimination of costly shut-downs—they have proven that the Keystone Venango Gravity Grease System and

KEYSTONE GREASE

THE MASTER LUBRICANT

"Makes the Most Efficient Mechanical Unit MORE Efficient"

Our engineers have solved a multitude of the most difficult lubricating problems that have ever arisen in the attainment of high industrial efficiency.

It may be that a troublesome lubrication problem is causing you an endless amount of worry right now. Write us in full detail today—we'll give you the benefit of a lifetime of experience in the entire field of lubrication engineering.

Where Efficiency
Counts and
Is Measured
—American
Industries
Move on
Keystone
Grease

KEYSTONE
TRADE MARK
Reg. U.S. Pat. Off.
GREASE
The Master Lubricant

THE KEYSTONE LUBRICATING COMPANY

Executive Office and Works
Philadelphia, Pa.
Established 1884

New York
Boston
Pittsburgh
Chicago
Detroit

St. Louis
Denver
San Francisco
Minneapolis
Montgomery, W. Va.

Agencies in Principal Countries Throughout the World

UNIVERSALLY KNOWN UNIVERSALLY USED

MORSE SILENT CHAIN DRIVES

THE MORSE "ROCKER JOINT"

A Preferred Investment

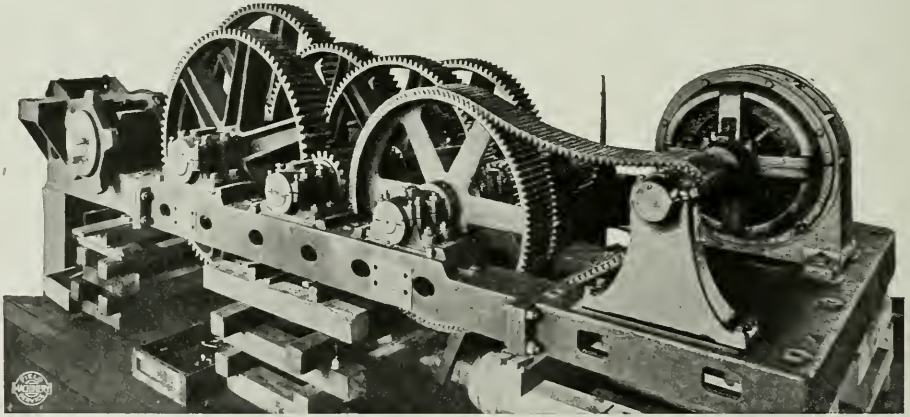
Extensively Used for Special Mill Machinery

The Vaughn Machinery Company of Cuyahoga Falls, Ohio, has been using Morse Chain Drives for the past ten years, in equipping its well-known line of steel and rubber mill machinery—principally on draw benches, wire drawing frames, pointers and calenders.

The Morse Chain shown is used to transmit power from a 17 tooth gear on a 100 H.P. motor, to a 113 tooth drive sprocket on the reduction gearing of a Vaughn Straightway 4″ Draw Bench—a distance of 60″ between centers.

Morse Drives run cool, oil baths not required, save power and space, increase production, allow better arrangement and reduce maintenance costs.

Morse engineers are power transmission experts with years of experience. They are ready to study and analyze your power transmission problem and will tell you frankly whether or not Morse Chain is the solution.



Benefit by MORSE SERVICE As Others Do.

Morse Chain Co. *Largest Manufacturers or Silent Chains in the World* **Ithaca, N. Y.**

Address Nearest Office

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Baltimore, Md.........1402 Lexington Bldg.
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Cleveland, Ohio...........Engineers Bldg.
Detroit, Mich..............1361 Abbott St.
Kansas City, Mo..........................Finance Bldg., Morse Engineering Co.
New York City..........................50 Church St.
Minneapolis, Minn....So. 3rd St., Strong-Scott Mfg. Co.
Montreal....St. Nicholas Bldg., Jones & Glassco Reg'd
Philadelphia.............................. Fuller Bldg.
Pittsburgh, Pa......................Westinghouse Bldg.
San Francisco, Cal......................Monadnock Bldg.
St. Louis, Mo...Chemical Bldg., Morse Engineering Co.
Toronto..Bank of Hamilton Bldg., Jones & Glassco Reg'd
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"Morse" is the Guarantee Always Behind the Efficiency, Durability and Service

Westinghouse

Patented Tuyeres

"They Defy Demon Heat"

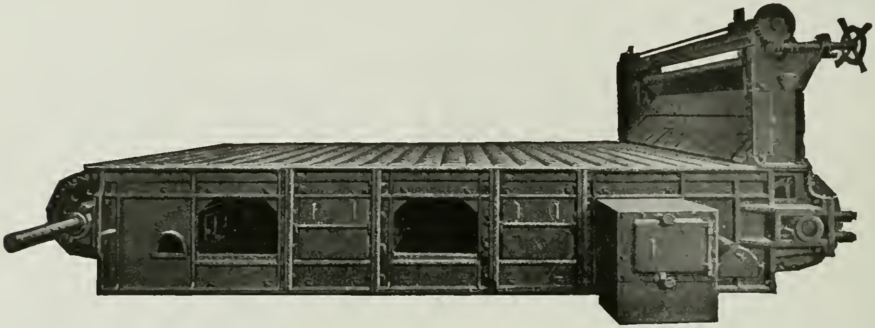
The Tuyeres used on Westinghouse Underfeed Stokers are designed so that contraction and expansion caused by varying heat intensities will not crack them.

This insures fewer replacements and lower upkeep.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.
Sales Offices in All Principal American Cities

—A careful consideration of details in the first place will mean a large saving in the long run.

DOUBLE DUTY



COXE STOKERS

are always ready for double duty; not only in regard to overloads but also in regard to the kind of fuel burned.

Bituminous Coal, Anthracite
or Coke Breeze

are all fuels that are being burned with Satisfactory Results on Coxe Stokers, day in and day out.

Get the Coxe Stoker Catalog.

International Combustion Engineering Corporation

Combustion Engineering Corporation

Combustion Engineering Building, Broad St., New York City

Lopulco Pulverized Fuel Systems
Type E Stokers—for Bituminous Coal
The Grieve Grate—Hand-Firing
Coxe Stokers—Anthracite Coal, Coke Breeze and Bituminous Coal

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Taylor Engineering Co., Vancouver, B. C.

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ESTABLISHED 1885
PISTON-TYPE MEASURING PUMPS

This Oil Savings Bank Will Pay You More Than 4%

Profits are governed by cost of materials, labor and operation. Bowser Oil Storage Equipment will show you how to cut the cost of labor and operation.

Bowser centralizes your oil storage and makes it easily accessible. Any unskilled workman can pump any amount of the desired kind of oil from a Bowser.

Oil pumped from a Bowser is bound to be clean. The tanks are built to keep out all dirt and factory dust.

All receipts and outgoing oil are registered so that an absolute check can be kept on the quantity used. And, because of the pumps, there can be no spillage in transfer.

Bowser Oil Batteries will pay you worth-while interest on your investment.

Write for Illustrated Booklet A-05.

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Dallas

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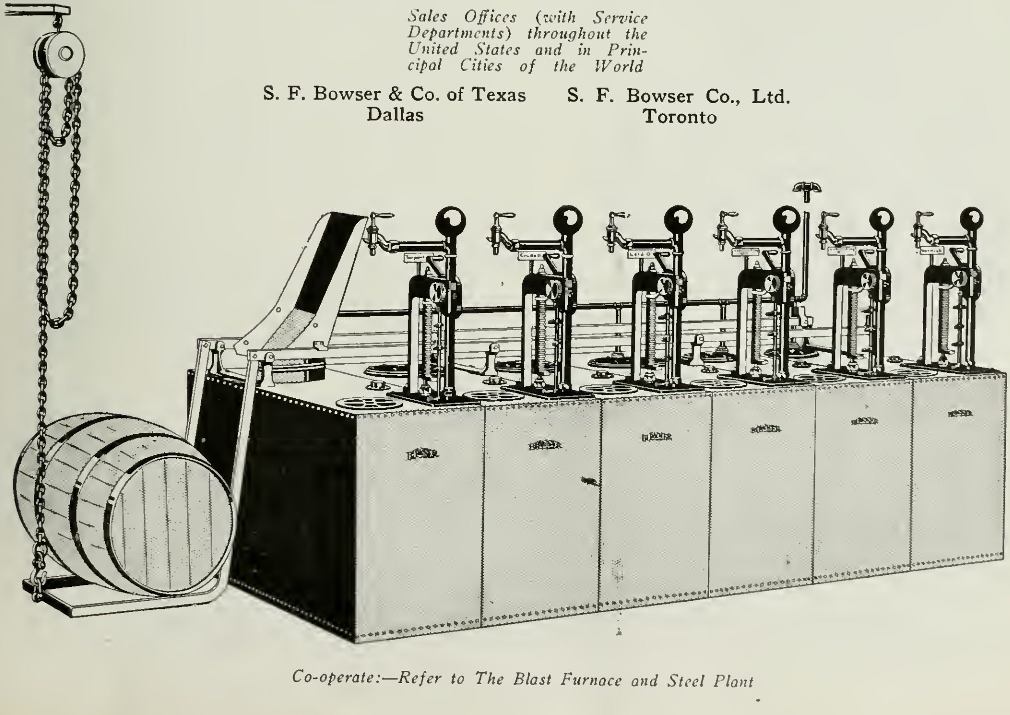
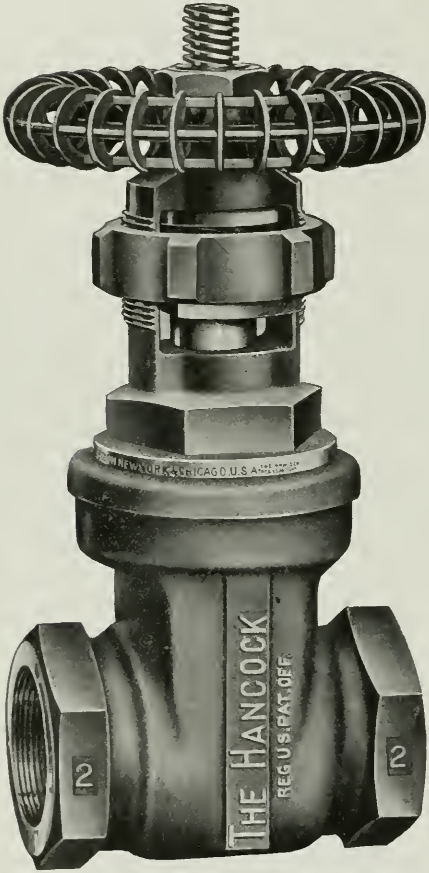


Hancock Quality Applied To Gate Valves



A Design Which Embodies All That Is Best In Modern Gate Valve Practice—

A design so good that the name "Hancock" can be put on it—a design that represents the last word in a Gate Valve for high pressure, high temperature service.

The Hancock Gate Valve is made with self-rising stem, yoke type bonnet, renewable seats and split wedge discs, either of bronze, nickel or monel, and with universal pressure packing gland. Bodies and yokes made of either the high grade temperature resisting bronze, which has made Hancock Valves famous, or of cast steel.

Hancock Gate Valves are all tested to 1000 pounds hydraulic pressure before shipment. They are made to withstand the most severe service to which a Gate Valve can be subjected.

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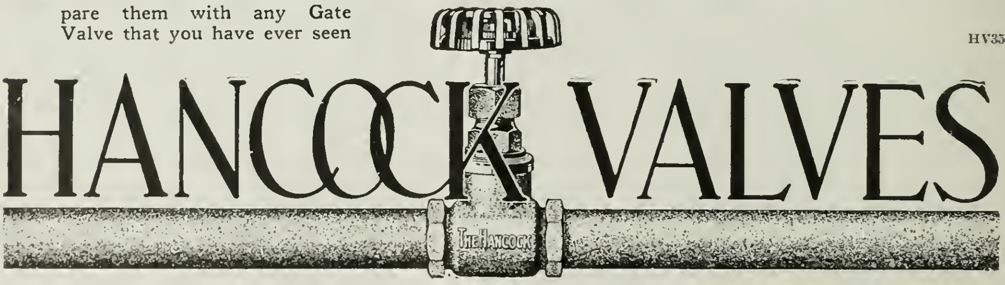
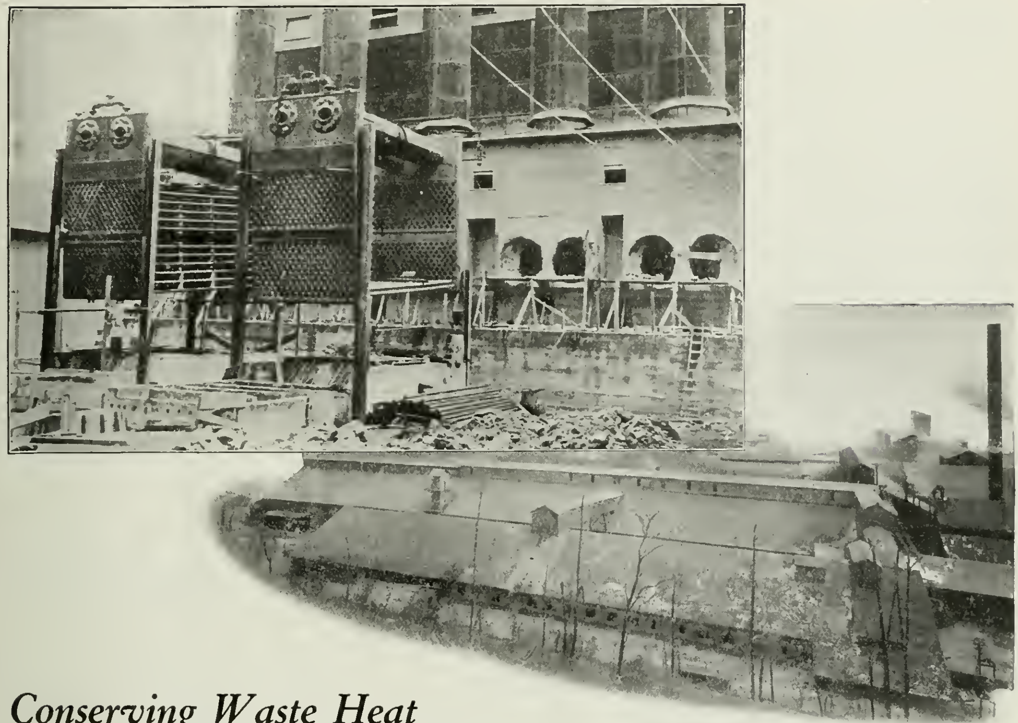
HV35





The upper illustration shows two Edge Moor Waste Heat Boilers having a total of 1498 H.P., in course of installation at the plant of the Alpha Portland Cement Co., at Alsen, New York. The lower illustration shows view of the Martin's Creek, Pa., plant of the same company where three 749 H. P. boilers have been installed.

Conserving Waste Heat

THE first waste heat boiler plant in the cement industry to attract widespread attention was designed and built by the Edge Moor Iron Company.

It was the first application of the Edge Moor principle to waste heat boilers. After starting this waste heat plant, the old boilers in the power house were shut down, being merely held in reserve as a stand-by plant in case of emergency.

Properly designed waste heat plants will pay for themselves in two or three years.

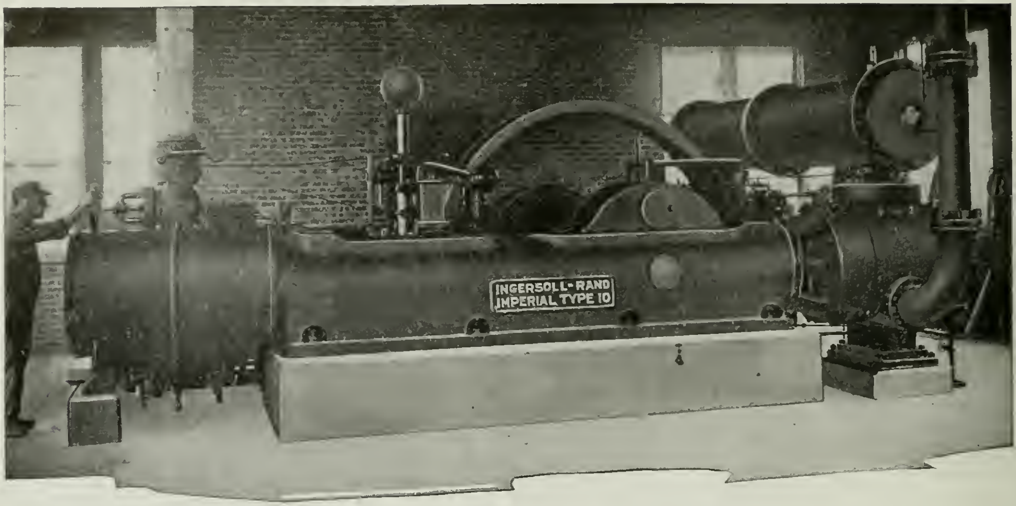
Similar power economies can be obtained in the steel, coke, lime, refractories and other industries by the installation of Edge Moor Waste Heat Boilers.

An interesting booklet on this subject will be mailed to you on request.

EDGE MOOR IRON COMPANY
Established 1868
EDGE MOOR, DELAWARE
New York — Boston — Chicago — Pittsburgh — Charlotte — St. Paul

EDGE MOOR

Water Tube BOILERS



High Economy Steam Driven Air Compressors

The compressor shown above is one of four 24-inch stroke Ingersoll-Rand Type XPV Air Compressors used by the Lehigh & Wilkes-Barre Coal Co. Each of these units has a piston displacement of 3,030 cubic feet per minute.

The Type XPV steam driven air compressor with automatic cut-off governor has steam economies equal to those of a full Corliss machine of the same capacity. The XPV piston valve permits the use of high steam pressures and superheat.

A unique feature of the machine is its efficiency at reduced loads. The steam rate per indicated horsepower increases only 3%.

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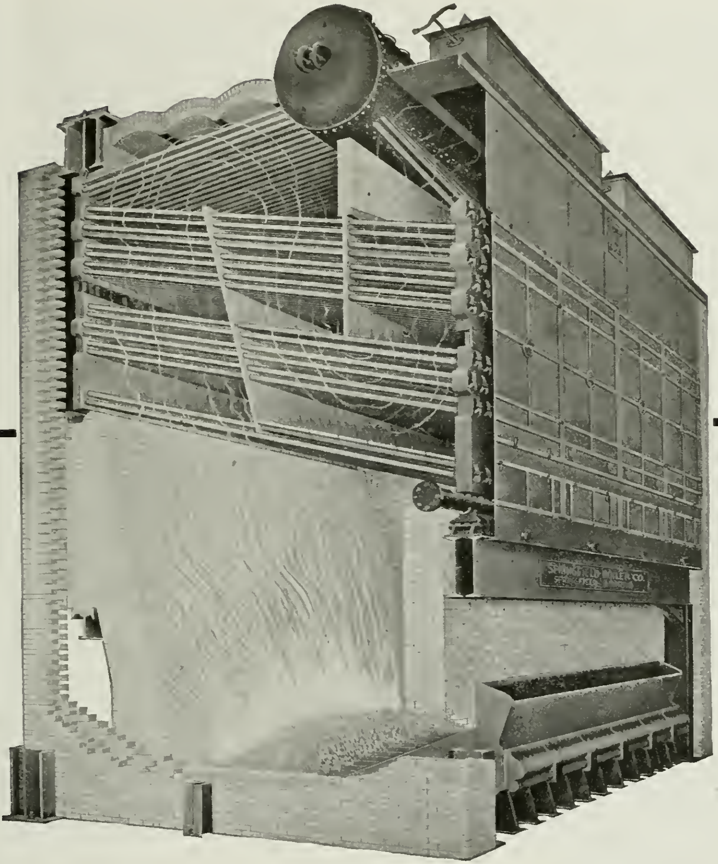

THE EFFECTIVE USE OF RADIANT HEAT

Careful consideration is given to the importance of direct radiation by large Power Users and Leading Engineers.

The boiler shown above is an exemplification of modern design towards this end; it shows a 1505 H.P. boiler of which we recently built two for the Youngstown Sheet & Tube Co., Youngstown, Ohio; we are now installing Twelve 1890 H.P. boilers of very similar construction for the United Electric Light & Power Co., New York City.

Let us tell you more about SPRINGFIELD boilers.

SPRINGFIELD BOILERS

Springfield Boiler Co.

Springfield, Illinois.

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LADD WATER TUBE BOILER

Ladd Water Tube Boilers

of the high arch type are daily proving themselves the most satisfactory and dependable boilers on the market.

A large combustion chamber makes for a complete burning of all volatile gases and the front bank of tubes is exposed to the radiant heat of the fire.

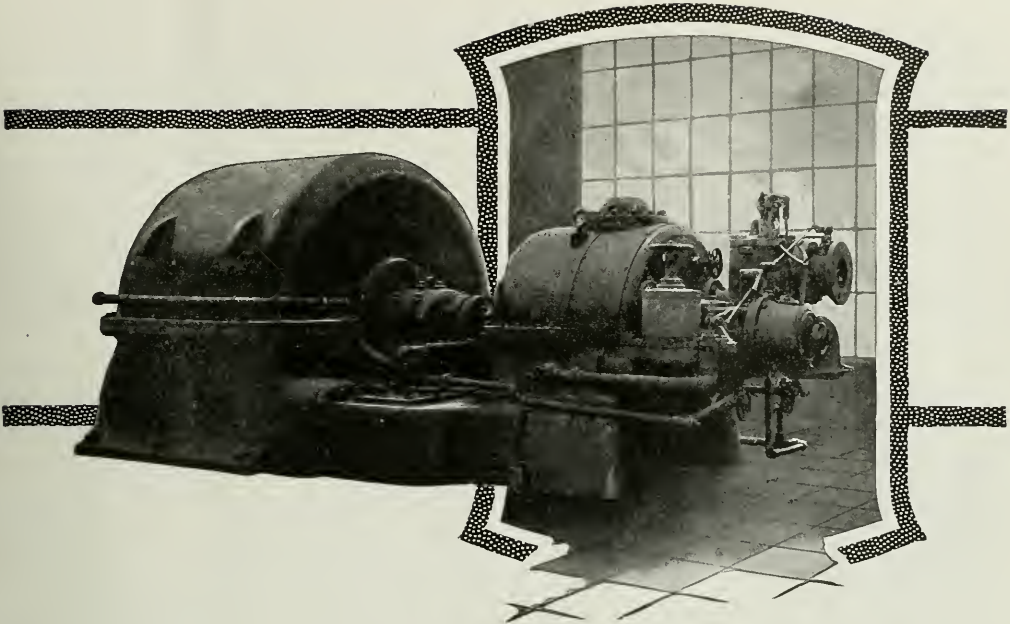
The baffling has been designed to give the most complete contact possible of the gases with the tubes and maintain low flue gas temperature.

As the superheater is placed in the combustion chamber fully protected by baffle brick, there is no draft loss through the superheater and the temperature of the steam is constant at all loads.

These and other features of LADD BOILERS are amply described in our catalogue.

THE GEORGE T. LADD CO.
FIRST NATIONAL BANK BUILDING
PITTSBURGH, PENNA.

CHICAGO OFFICE: 528 McCORMICK BLDG. CHICAGO, ILL.



Turbo Gas Exhausters and Boosters

STEAM turbines, because of their high speed characteristic, are ideal for driving blowers and compressors. Their flexibility permits highly efficient operation regardless of the variation in quantity of air or gas desired. This is because the speed of the turbine may be controlled so that the blower or compressor will deliver any quantity within its range at the desired pressure without the throttling, which is so detrimental to high efficiency.

Terry turbines are furnished in sizes up to 1,000 H.P., condensing or non-condensing, for this class of service.

There are more than eighteen hundred Terrys now in operation, driving exhausters, boosters, blowers and fans for many different classes of service.

Write for Bulletin 25

T-739

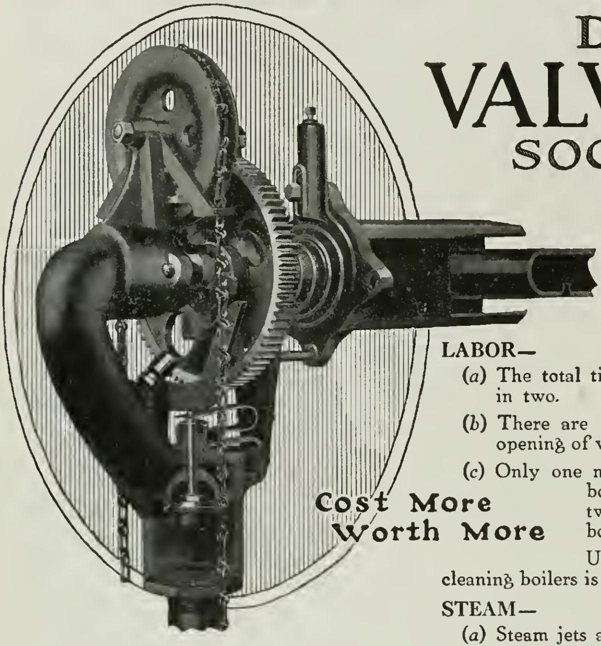
THE TERRY TURBINE

Offices in Principal Cities
in U.S.A. also in Important
Industrial Foreign Countries

The Terry Steam Turbine Co.
Terry Sq. Hartford. Conn. U.S.A.

40 to 50% Saving on Labor and Steam

DIAMOND
VALV-IN-HEAD
SOOT BLOWERS



**Cost More
Worth More**

Important mechanical features of the Diamond Valv-in-Head soot blower are: Monel metal valve seat and disc; full floating construction permitting movement of the unit in any direction; control of speed through reduction gearing; ease of operation due to ball thrust bearings, etc., etc.

COST of labor and steam are two important items in soot blower operation. Note how the Diamond Valv-in-Head cuts these costs in half:

LABOR—

(*a*) The total time required for blowing is cut squarely in two.

(*b*) There are no lost steps and no lost time between opening of valve and operation of unit.

(*c*) Only one man is required, no matter how large the boiler. (With other types of blower heads two men are customarily employed on large boilers).

Under these conditions the cost of labor for cleaning boilers is comparatively small.

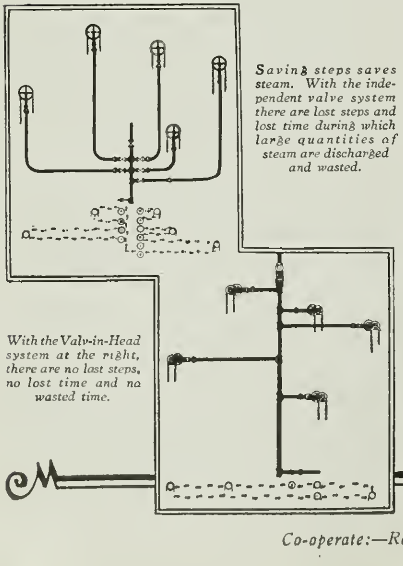
STEAM—

(*a*) Steam jets are revolving throughout the entire blowing period.

(*b*) Speed of rotation is controlled by gear reduction. No waste of steam occurs as the result of too slow or too rapid operation.

(*c*) Globe valves, essential to other heads, require many valuable moments to open and close, during which steam is wasted. The automatic operation of the Valv-in-Head eliminates losses.

The saving in steam with the Valv-in-Head is pronounced, because every bit of steam does effective work in cleaning the boiler.



Saving steps saves steam. With the independent valve system there are lost steps and lost time during which large quantities of steam are discharged and wasted.

With the Valv-in-Head system at the right, there are no lost steps, no lost time and no wasted time.

These are only two of eleven important advantages of Diamond Valv-in-Head soot blowers. Others include savings in pipe, valves and fittings, maintenance, gain in cleaning efficiency, etc., etc.

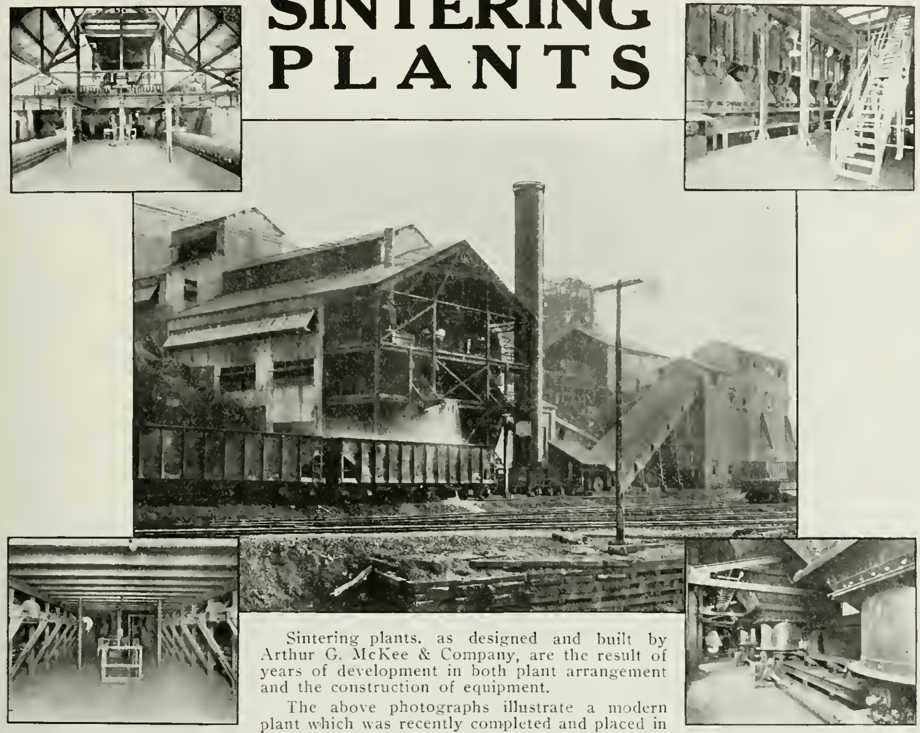
Every boiler needs a mechanical soot blower and you will save money by buying the best. Ask for your copy of Bulletin 257 describing the new blower.

DIAMOND POWER SPECIALTY COMPANY
Detroit, Michigan

Diamond

SOOT BLOWERS - SAVE 4 to 8% FUEL

SINTERING PLANTS



Sintering plants, as designed and built by Arthur G. McKee & Company, are the result of years of development in both plant arrangement and the construction of equipment.

The above photographs illustrate a modern plant which was recently completed and placed in operation, and which embodies the latest developments in the art of sintering. Large tonnages of excellent sinter are being produced at this plant and the ideal arrangement of equipment reduces handling charges to a minimum. The plant is equipped throughout with the most rugged machinery, specially designed to satisfactorily meet the severe conditions imposed in handling continuously abrasive and dusty material.

If you are interested in sintering, our organization is equipped to handle your entire program, including the preliminary investigation, preparation of designs, and the furnishing and erection of materials.

We will be very glad to furnish balance sheets, cost data or estimates upon request.

BLAST FURNACES
STEEL MILLS AND
AUXILIARY EQUIPMENT

Arthur G. McKee & Co.

ENGINEERS & CONTRACTORS
2422 EUCLID AVE.
CLEVELAND, O.

- Blast Furnaces
- Hot Blast Stoves
- Storage Bins
- McKee Revolving Distributors
- Power Plants
- Kling Weidlein Dry Gas Cleaners
- Sintering Plants
- Scale and Transfer Cars
- Rolling Mills
- Open-Hearth Furnaces

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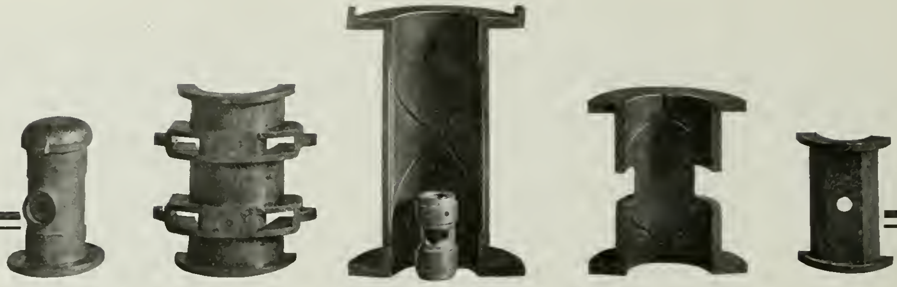
Reports—Appraisals—Investigations



Have you ever considered the savings which you can effect by the use of

Noheet METAL

DIE CAST BEARINGS?

They eliminate all machine work and are guaranteed to be free from blow-holes and true dimensions.

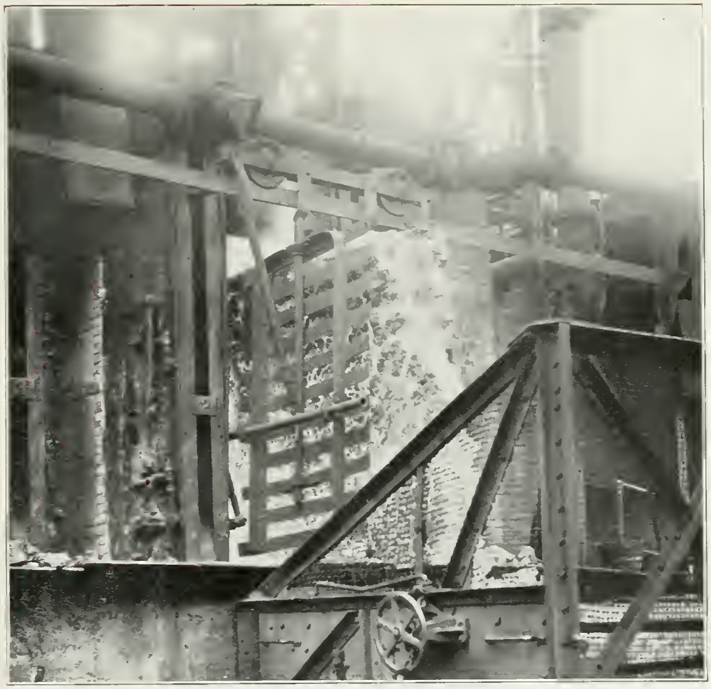
We die cast bearings from the smallest sizes up to 10x20″ for motor, presses, roll and run-out tables, wire drawing and coal handling machinery, pumps, etc.

Let us quote on your requirements.

The Lubricating Metal Company

2 Rector Street, New York

Pittsburgh **Chicago** **Cleveland**



Semet-Solvay Plant at Holt, Ala.

No. 2 Oven is closed down for minor repairs for the first time in seven years!
No. 1 and No. 3 are still in run—see oven No. 1 being pushed.

Why the Strong Division Walls

The inherent strength and durability of Semet-Solvay By-Product Coke Ovens are due to the strong division walls. Each oven is practically a Plant in itself and may be shut down, repaired, and started up at will. Consider this tremendous advantage in operation efficiency, especially in small plants.

Correspondence is invited

Address Plant Development Department

SEMET-SOLVAY COMPANY, Syracuse, New York

1891—Pioneer in the Development of the By-Product Coke Oven—1921

BY-PRODUCT COKE OVENS

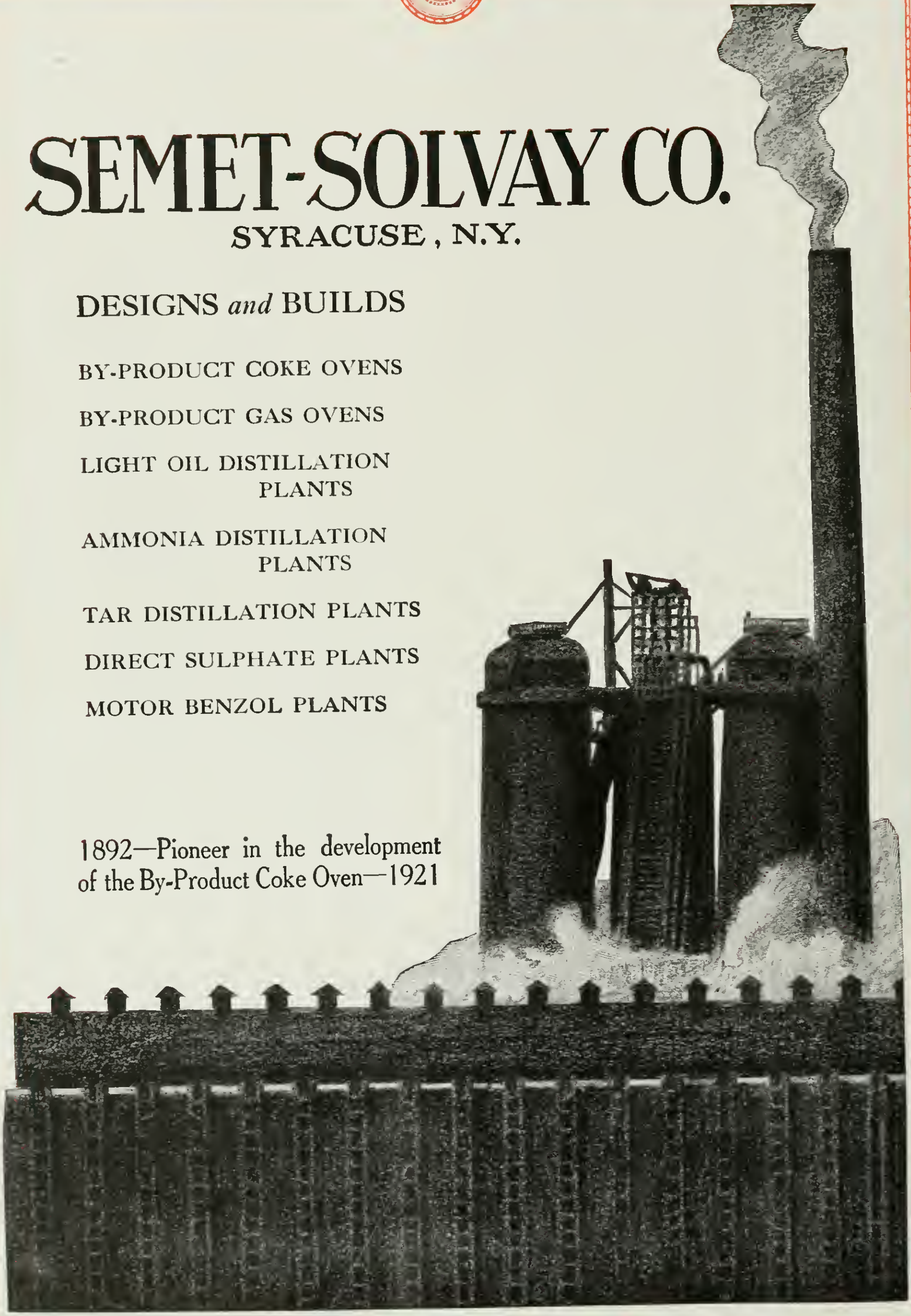
SEMET-SOLVAY CO.

SYRACUSE, N.Y.

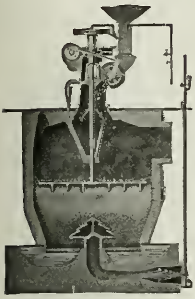
DESIGNS *and* BUILDS

- BY-PRODUCT COKE OVENS
- BY-PRODUCT GAS OVENS
- LIGHT OIL DISTILLATION PLANTS
- AMMONIA DISTILLATION PLANTS
- TAR DISTILLATION PLANTS
- DIRECT SULPHATE PLANTS
- MOTOR BENZOL PLANTS

1892—Pioneer in the development of the By-Product Coke Oven—1921



How can I Reduce the Cost of My Product?

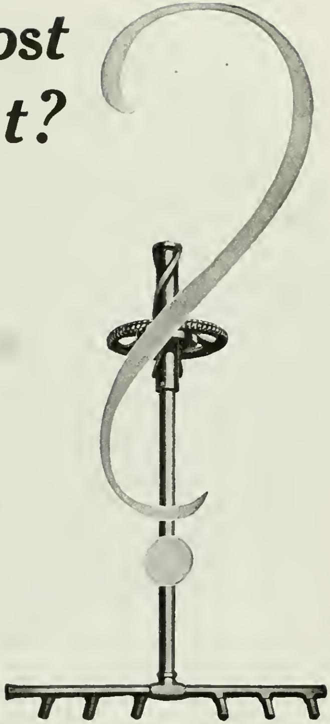


FUTURE sales in a strongly contested market depend upon the ability to manufacture a product at the lowest cost.

Chapman Gas Producers and Chapman Floating Agitators are reducing fuel bills 20 per cent and eliminating 50 to 75 per cent of the gas house labor. This feature of their success has not been so greatly appreciated until now. The majority of the 650 units now in operation have been bought to increase capacity, make working conditions cleaner and more healthful, or to insure a more uniform supply of producer gas. But now--now they are being bought because they reduce the selling price of the finished product.

Chapman Gas Producers and Chapman Floating Agitators for old hand-poked producers are standardized machines, built in quantity lots on a low cost basis, and sold from stock. The selling price is therefore low. This with the saving they make has often allowed them to pay for themselves during the first year's operation.

Allow the Chapman Organization and Chapman Equipment to help you reduce the cost of your product.



The

CHAPMAN ENGINEERING CO.

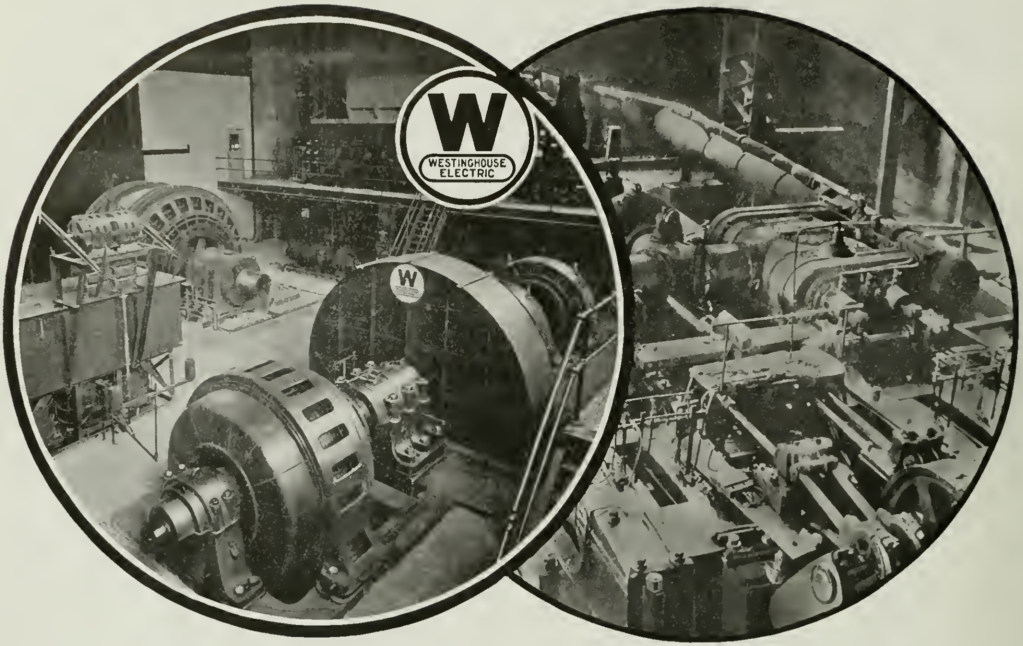
Division of The

C&G COOPER CO.

MT. VERNON, OHIO.

50 Church St., New York

Oliver Building, Pittsburgh



How Should The Present Be Utilized?

Healthy business revival, in strict accordance with sound adjustment, is well under way. In a short while we shall see the passing of the present lull which affords the opportunity for necessary rehabilitation.

It is, therefore, encouraging to see this opportunity for improvement capitalized. Repair, replacement and electrification of mills are well under way and good times will find the steel industry equipped to meet keener competition with equipment of higher productive efficiency.

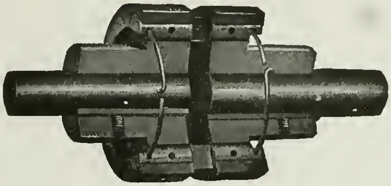
Westinghouse engineers will gladly give your individual mill power problem careful consideration.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.
Sales Offices in All Principal American Cities

Westinghouse

FRANCKE FLEXIBLE COUPLINGS

Eliminate Excessive Friction Losses and Cushion Load Shocks



Heavy Pattern, or Single, Francke
Flexible Couplings for All
Ordinary Shaft Drives

Friction means wear and waste of power. Misalignment magnifies it—multiplies these losses.

Load shocks, communicated to machines, put strains upon them that they were not designed to bear, often resulting in breakage.

Eliminate excessive friction by providing for shaft misalignment. A **Francke** Coupling will do it.

Cushion load shocks by using a **Francke** flexible coupling. It's flexible—in three directions—shock absorbing.

Back of every **Francke** Coupling there's a coupling knowledge gained in furnishing couplings totaling over three million horsepower.

We have experienced men to consult with you about your coupling problems—right on the ground if you wish.

Others have used this service
for years. May we serve you?

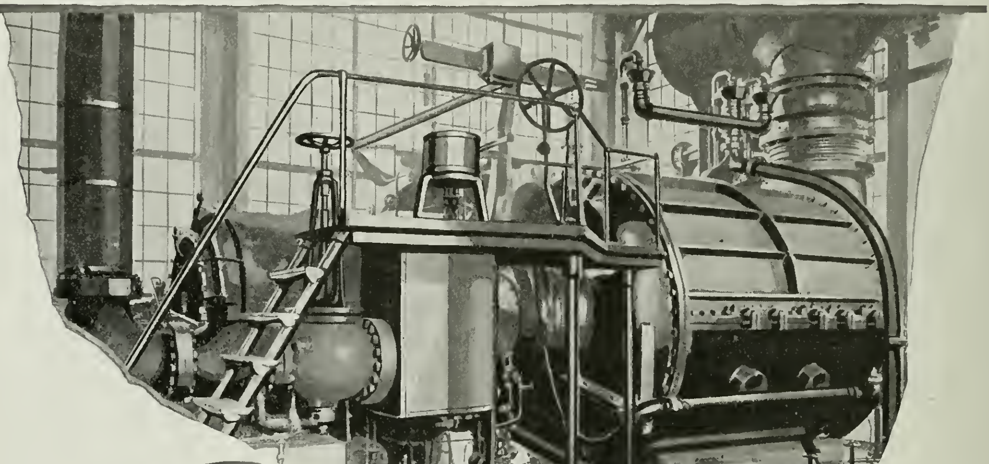
New Bulletin No. 32 lists prices now at June, 1918, level.

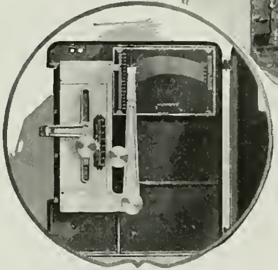
SMITH AND SERRELL

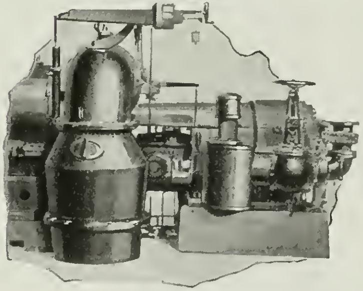
34 Central Avenue Newark, N. J.

Pintite Rigid Couplings for Line Shafting

Steadier and accurately measured blast gives better conditions in the blast furnace, which leads to increased output and improved quality







For most efficient service use G-E Centrifugal Blast Furnace Blowers

The G-E blower pictured above provides air for a 600 ton furnace, and offers a method of attaining better furnace conditions which is attended with lower first cost and lower operating cost as compared with the apparatus it displaces.

A further advantage consists in providing an accurate measurement of flow of air into the furnace as contrasted with the inaccuracies of estimation by displacement.

Uniform furnace conditions are maintained by virtue of the accurate constant volume governor shown in the illustration at the left and its volume corrector, an enlarged picture of which is in the circle just above the governor.

G-E Centrifugal Blowers operate with less attention and are more flexible in service than any other form of blowing apparatus for blast furnaces. Further details may be obtained from the nearest G-E office.

General Electric Company

General Office
Schenectady, N.Y.

Sales Offices in
all large cities 43B-616

The Blast Furnace and Steel Plant

The Blast Furnace and Steel Plant

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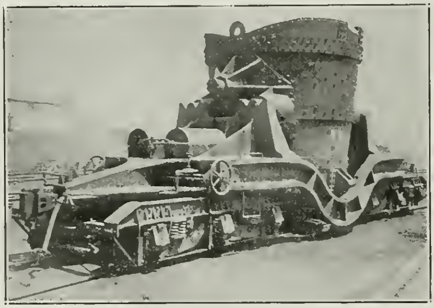
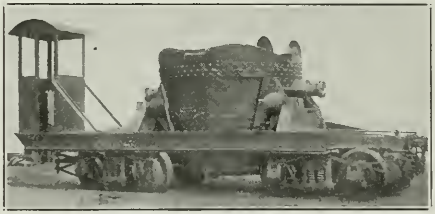
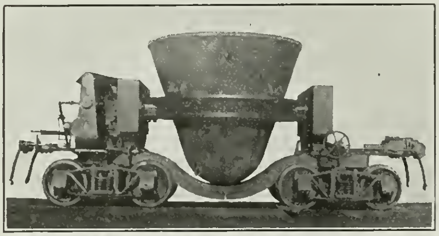
PENNSYLVANIA
LADLES and CARS
for Blast Furnace and Steel Plants



75-Ton Hot Metal Car



65-Ton Metal Transfer Car



320 cu. ft. Cinder Car

Hot Metal Ladle Cars

Cinder Cars

Ore Scale Cars

Electric Transfer Ladle Cars

Ingot Mould Cars

O. H. Charging Box Cars

Pig Metal Cars

Converter Jack Cars

Ore Transfer Cars

Blast Furnace Skip Cars

Bottom Oven Cars

Ladles 25 to 125 Tons

Designed and Built by

Pennsylvania Engineering Works
New Castle, Penna.

Builders of Blast Furnace and Steel Mill Equipment.

The Blast Furnace and Steel Plant

Vol. IX PITTSBURGH, PA., DECEMBER, 1921 No. 12

American Iron and Steel Institute Meeting

Gary and Schwab Laud Aims of Arms Hope—Judge Gary Predicts Prosperity—Several Valuable Technical Papers Also Presented

THE twentieth general meeting of the American Iron and Steel Institute was held at the Commodore Hotel, New York, on November 18th. There were three sessions. The forenoon and afternoon sessions being devoted to the address of Judge Gary and the reading of a number of technical papers. In the evening the banquet was held as usual. The feature of the banquet being an address by Marshall Foch. The technical program presented at this meeting was interesting and consisted of the following papers.

Papers.

"Steel Lumber," Thomas J. Foster, chairman National Bridge Works, Long Island City.

"Welding," S. W. Miller, president American Welding Society.

"The Relations of the Iron and Steel Industries to the Chemical Industry," J. M. Camp, director Bureau of Technical Instruction, Carnegie Steel Company, Pittsburgh, Pa.

"Refractories in the Steel Plant," W. A. Hull, Bureau of Standards, Washington, D. C.

"Direct Process for Steel Manufacture," A. E. Bourcoud, metallurgist, 200 Fifth Avenue, New York City.

"Improvements in Port Construction in Open Hearth Furnaces," J. W. Kagarise, Edgar Thomson Open Hearth Department, Carnegie Steel Company, Braddock, Pa.

Abstracts of the papers which were read are contained in this issue of "The Blast Furnace and Steel Plant."

Judge Gary in his address urged that the Washington Conference go beyond an agreement for the limitation of armament and enter into a final treaty which would prevent future wars. He advocated an international understanding after the discussion of disputes between Nations before resorting to arms.

The 1,500 members cheered when the steel leader predicted success for the conference, not only per se, but in reducing the burden of taxation and causing a return to normal living conditions. Even a 50 per cent reduction in expenditures for military purposes, he said, would be a "prodigious" saving. He doubted whether there would be any decrease in the production of steel because of the limitation of armament. If any, it would be small. On the other hand, he asserted, world peace would "mark an epoch of the greatest business prosperity, as well as the largest measure of happiness, that the world has ever witnessed."

Judge Gary said that he was very "hopeful" about business and industry. Things have been growing better for the past six months and the volume of business in the steel industry has more than doubled in the last days. All in all, he expects "a return to large prosperity in the comparatively near future."

But he said that certain factors are holding back a return to normal—chief of them, taxation. He warned that any politician or party that stands for the present tax rates or opposes substantial reductions may expect defeat at the next election.

Favors Sales Tax as Fair.

"Our government is called upon as never before," he said, "to reduce expenses and expenditures and to modify and clarify taxation. The burdens are greater than we can long endure."

He favored the sales tax as fairest and cheapest to administer.

Among the other obstacles in the way of prosperity he discussed the high costs of living, profiteering by middlemen in food, clothing and shelter, high costs of production and transportation, high prices of materials and high wages.

Lauds Marshal Foch.

At the institute dinner tonight to Marshal Foch, Judge Gary hailed the noted guest as the deliverer of mankind.

"God grant that the conference at Washington will finally bring about conditions which will establish and maintain continuously and permanently peace between all nations," Mr. Gary said. "And that the guest of honor here this evening may have the pleasure of exercising a strong influence in this dinner. The men of affairs here assembled, appreciate from experience what it means to a large enterprise to have perfect cooperation of forces and perfect system in management, and they know how easy and simple to control it seems to outsiders, especially those of little practical knowledge, if the business is successful and moves without internal fiction."

Steel Men for Peace, Schwab Says.

Emphatic assurance that the iron and steel manufacturers of the United States are solidly aligned with delegates to the Arms Conference in their efforts to end wars, was given by Charles M. Schwab in an address at the dinner.

After paying high tribute to the Marshal and telling him he had been "grappled to our souls with hoops of steel," Mr. Schwab said:

I would like to take advantage of this occasion to say something which has long been upon my heart, and which at this significant moment it is clearly my duty to say. It was stated at some of the sessions of the recent League of Nations meeting in Geneva, it has often been carlessly suggested in the press, that the flame of war is in great measure kept alive by those interested in the private building of naval ships and the manufacture of munitions of war.

Thrilled by Hughes' Speech.

I can, of course, speak only for myself, but I believe I know and express the sentiments of others placed in similar positions to mine when I say this:

I am at the head of the largest war materials manufacturing works in the world. The shipyards of my company build more naval ships than are built in any other yard under one management in the United States. But I have been thrilled beyond expression, as has every good American, by the brilliant and statesmanlike scheme laid before the conference at Washington by Secretary Hughes. The carrying out of that plan may involve great monetary loss in some quarters, but such a thing as financial loss can be of no consideration when compared to the inestimable boon to mankind which would be involved in the realization of that magnificent plan.

Mr. Schwab declared that should the statesmen now assembled in Washington make it possible to bring about disarmament and permanent peace, gladly would he see "the war-making machinery of the Bethlehem Steel Corporation sunk to the bottom of the ocean." Nothing could contribute more to the permanent prosperity and happiness of the world, he added, than the conclusion of agreements among the nations of the world which would eliminate the curse of war.

"So," he said, "let us say to the men gathered at Washington, let it go out from this gathering of men of the steel and iron industry, that we are solidly behind every effort they can make which will hasten the coming of the time when war shall be no more.

Will Accept Loss Willingly.

"If disarmament inflicts a money loss upon us, the American iron and steel industry will accept it willingly and gladly. We will do so not in a spirit of mere idealism and self-sacrifice, but in a belief that the greatest permanent, material prosperity would be brought about by the concentration of the energies of mankind upon constructive activities; upon means for well-being and not for the destruction of civilization."

Improvements In Port Construction In Open Hearth Steel Furnaces

New Port Construction Which Has Increased the Efficiency of the Open Hearth—The McCune and the Engler Furnace Construction Thoroughly Described

By JOHN W. KAGARISE
Superintendent, Open Hearth Department
Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.

THE proper operation of an open-hearth furnace is nowhere more dependent upon good design than in the ports, and especially is this true with furnaces using producer gas as fuel. By far the larger proportion of furnace trouble originates in the ports, and even when perfectly designed as to size, arrangement and alignment, it is a difficult matter to keep them so.

In the pioneer days of the open-hearth, producer gas was the chief fuel used, and it was the practice of furnace builders to follow a rule of thumb formula for the construction of the port ends with the inevitable result that very little progress was made toward the solution of this most important problem.

Both ends of the furnace, alternately, are subjected every few minutes to the outgoing rush of intensely hot gases, laden with particles of iron oxide, lime, slag, etc., at a comparatively high velocity, due to the area of the port openings being relatively small compared to that of the hearth.

The temperature required in the steel bath at tapping is 2,900 deg. to 3,000 deg. F. (1,593 deg to 1,639 deg. C.), the flame temperature required is 3,100 deg. to 3,300 deg. F., and the fusion point of the silica brick, of which the ports are built, is from 3,300 deg. to 3,400 deg. F. This is a very narrow range with which to work at such high temperatures, and the action of the waste gas passing out of the furnace cuts back the ports very rapidly. There are numerous instances where furnaces have had to be shut down for repairs after making comparatively few heats. Many were the attempts made to remedy this fault and schemes beyond number have been tried to lengthen the life of the furnace.

Port Design of Early Furnaces.

The first furnace in America to make open-hearth steel as a commercial success was a five-ton furnace using producer gas fuel, designed by the late S. T. Wellman and built by the Bay State Iron Works of South Boston, Mass., in 1869. The builders made no attempt to direct the flow of the gas by the lines of the port, but depended on the depressed roof over the furnace to force down the flame into contact with the bath. The roof burned away very rapidly, the heat transfer to the bath was poor, and the life of the furnace was short.

From this time forward there were many changes in the port construction, and gradually the ports came to be built with both the gas and air openings inclined downward toward the hearth, the air being inclined to a greater degree than the gas. This construction caused the air to flow down sharply on top of the gas, kept the flame in close contact with the bath and also tended to protect the roof.

While these furnaces were a big improvement, still their life was short, and to overcome the short runs the gas arch was built longer, or nearer to the combustion chamber, to give more brickwork to wear away. This type of furnace worked slowly at first; as the long port caused the hottest part of the flame to be carried well out over the bath, the incoming end worked coldly and the gas was not fully burned before it passed out of the furnace. As the blocks and arches wore away, shortening the port and increasing the length of the combustion chamber, the furnace gained in speed and became a good working furnace. When the furnace run had lengthened and the port had burned very short, the flame was not directed properly and traveled close to the roof, soon putting the furnace out for repairs.

To prolong the life of the furnace, sand ports were often put in by placing a pipe in the port and ramming silica sand, mixed with lime or molasses, over it, to conform to the desired lines. The furnace was then heated up slowly and the pipe burned out. By the time the pipe was burned out, the sand was set, and if it did not crumble, the furnace generally made fair time on the heats. However, the life of a sand port was very irregular, a constant source of worry, and very often the cause of break-outs through the end of the hearth and serious damage to the furnace.

At several plants, the furnaces were so designed that a removable port was used. This removable port was built in a rigid framework which held all the brickwork above the charging floor level to the end of the furnace proper. A spare port was always ready and, when necessary, a burned-out port was removed and a new one installed. This type of port is practically out of existence and nearly all producer gas furnaces today use a port with a single gas opening, which is built as an integral part of the furnace.

There is no doubt that, if a properly designed brick port could be maintained, the uncooled brick port makes the most efficiently working furnace.

Water-Cooled Ports.

The result of these experiences naturally led to experiments with water-cooling devices to protect the brickwork at its vulnerable parts. Water-cooling had been in successful use at the blast furnaces for years, and naturally some of the earliest port cooling was tried with bronze blast furnace cooling plates buried in the brickwork. The effect of this cooling was an improvement in the life of the furnace while the plates lasted, but generally the life of the plates was short; and they were a complete loss, as they could not be removed when they started leaking and the water supply had to be shut off.

This led to water-cooling with steel pipes of various sizes, each pipe connected to its own water supply, so that when a pipe started leaking and the water was shut off, the loss was not great. Some of the early types of pipe cooling devices which have been developed and are now in successful use are the small pipe ports developed and at present in use at the South Chicago Works of the Illinois Steel Company, the so-called Parks port developed at the Duquesne Steel Works of the Carnegie Steel Company, and now in service at that plant and at the Edgar Thomson Works of the same company, and the 8-inch flattened pipe block and arch cooler developed at the Gary Works of the Illinois Steel Company and Farrel Works of the Carnegie Steel Company, and now in service at the Farrell Works, the Ohio Works and at the Edgar Thomson Works in connection with the Parks port.

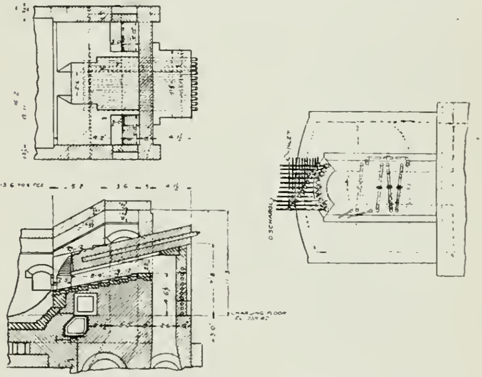


Fig. 1—Park water cooled port used at Duquesne and Edgar Thomson Works of the Carnegie Steel Company.

South Chicago Water-Cooled Ports.

About the earliest record we have of water-cooling devices is that of the small pipe coolers used at the South Chicago Works of the Illinois Steel Company. The water used at that plant is taken from the lake and is always clean and leaves very little deposit in the coolers. The first water-cooled ports put into operation were 1-inch pipes and were installed in No. 1 Open-Hearth Department, when they changed from natural to producer gas in 1903. The pipes were straight, were located at the mouth of the port and only cooled the front of the port arch. The pipes were later bent to cool the two sides and top of the gas port mouth.

Still later the pipes were brought through the port blocks at different elevations, one pipe behind the other, to protect the block, and all bent to cool the port on the two sides and top. This latter type port, with a few modifications, has been in use for the past eight years, and gives a life of from 300 to 400 heats.

Parks Port.

In the fall of 1909, water-cooling devices were tried in the ports of the open-hearth furnaces using producer gas at the Duquesne Steel Works. The original dry port arch of their furnaces was formed of 13-inch silica brick. For the water-cooled port, an arch of 9-inch brick was laid the length of the gas port; four pipes, four inches in diameter, with their furnace ends welded shut, were laid on top of the arch and the water was fed into them through a 1-in pipe, close to the welded end: the water, passing out of the cooler through a fitting on the outer end, was used for cooling the doors and frames. These pipes were spaced equally on the 9-inch arch and the space between filled in with brickwork. This scheme worked very well and good runs were made on the furnaces in comparison with dry ports. At times the gas would leak up through the arch between the pipes, but patching was easily accomplished. A mixture of magnesite and chrome ore was used in patching, and one port was put in with this mixture with very good results, but it was too costly. The experiences with the four pipes in the ports, and the leaking of the gas through the arch between the pipes, led to the adoption of the present Parks port. This port, as shown in Fig. 1 is constructed by laying the four-inch pipes as close together as possible, leaving just enough room to remove a leaking cooler and replace it with a new one. The pipes, of which it takes eleven to cover the arch, are covered with a 4½-inch arch of brickwork.

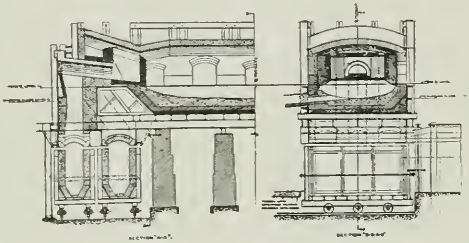


Fig. 2—Latest design of the Blair water cooled port.

The condition of the cooling water at the Duquesne Works and Edgar Thomson Works is very bad at times, as considerable foreign matter is pumped into the lines and a number of cooling pipes are lost. With this arrangement the cooler can be changed very quickly, and the life of the port averages from 300 to 400 heats.

In addition to the ports here described, there are several water-cooled ports on the market, the two best known being the Knox port and the Blair port.

Knox Port.

In the year 1906, Mr. L. L. Knox became interested in the subject of water-cooling and for several years devoted his entire time to study and experiment with the object in view of designing a port that would outlive the rest of the furnace.

Among his early attempts along this line was the introduction of a hollow copper casting over the top of the gas port, through which a constant stream of water was kept in circulation. While this served to keep the gas and air separate until they reached the combustion chamber, it did not prevent the sides of the gas port from becoming distorted and burning away. Side coolers were then added, which extended down to the floor of the port opening.

This design met with a fair amount of success, but the first cost of the copper castings, coupled with the expense of repairs, made it almost prohibitive.

Mr. Knox then turned his attention entirely to welded steel plate construction. From the very first it was found that steel plates have all the qualities of strength, ductility and conductivity that make them especially applicable for the purpose, and that they could stand contact with furnace slags and oxides without injury. Port coolers manufactured from rolled steel plates and designed practically similar to those of the copper castings were made for several years with varying success.

During the year 1911 the cross port cooler was designed along somewhat different lines. The cooler was carried across the port next the furnace and extended through the front and back walls. This gave access to the water connections and made it an easy matter to clean out the sediment that always deposits itself at the low places. A brick-lined opening was provided through the center of the cooler, which opening forms the mouth of the gas port.

Many improvements have been added from time to time, the most important of which was the lowering of the wings on either side of the central opening, or gas port. This allows the floor of the air port to be built to a very much lower level, thus providing a means of more completely surrounding the incoming gas with the hot air from the furnace checkers.

Blair Ports.

The port as first designed consisted of a flat, water-cooled, welded steel hood, and when installed in the basic furnace, the whole end blocks, ports and uptakes were built of ground magnesite. The gas port arch was replaced by the hood, which rested on each side of the port on the magnesite block, covering the gas port completely, and having an insulation of ground magnesite on its upper side, so that all seams in the hood were protected from contact with the flame. The hood was carried forward to the point at which the greatest efficiency and fuel economy were secured. If installed in an acid furnace, the end blocks could be built of silica sand or brick, the water-cooled hood replacing the brick arch.

The first installation was made at the Lackawanna Steel Company's Works in Buffalo, N. Y., in July, 1907, and was so successful that it was followed by other installations, until in 1913 this type of port was used in the building of the 250-ton tilting furnaces and up to January, 1919, six years, the original ports were still in use.

While this type of port was successful for a number of years, it was found that the life of the port was limited by the destruction of the magnesite side walls, so the later form of port, as shown in Fig. 2, with the semi-circular hood cooler forming the complete gas arch and side walls was adopted, and to a great extent decreased the use of magnesite in the port ends, thus greatly reducing the cost of construction.

The types of water-cooled ports just described are successful, and there are others in service which are doing good work, but it is impossible to describe them all; and it is a fact that no manufacturer in this country would consider building a modern open-hearth furnace without installing water-cooling in the ports, the type of the port to be selected to be determined by the engineers, governed by their fuel, water and local conditions, keeping in mind the fact that the best water-cooling is that which protects the vulnerable parts of the ports, and yet exposes the minimum amount of surface to the hot gases.

Ports for Burning Liquid Fuel and Powdered Coal.

The burning of oil, tar and powdered coal as fuel for open-hearth furnaces has been in practice in this country for a number of years. Their efficient burning depends more on the burner used, and its ability to properly atomize the fuel and direct the flame, than on the port construction. Water-cooled burners, which obviate the necessity of removal after each reversal, have been installed in furnaces with ports built for producer gas and natural gas, with modifications of both, and with ports built especially for these fuels, but the fuel consumption and furnace life are practically the same.

Developments in Methods of Burning Fuel.

The use of by-product coke oven gas as an open-hearth fuel introduced new difficulties in flame control and efficient combustion of the gas. As a result, in the last few years, many experiments have been made in changing the lines of the furnace ports * to more intimately mix the gas and air, thereby getting quicker combustion, or by the introduction of dampers in the ports or uptakes, to restrict the incoming air to a small area and thereby give it a high velocity, with the idea in view of burning the fuel with more efficiency. Such ports are primarily intended to be used with furnaces burning by-product gas and producer gas, but may be used for burning other fuels with some degree of success. Such relations were illustrated in principle, in 1912, by Mr. C. A. McCollum of the Homestead Works, and stated by him, in a report covering the efficiency of a furnace, as necessary with forced draft and desirable under all conditions.

Among the many experiments that have been tried and seem to be standing the test are the McKune System, the Venturi Line Furnaee and the combination of the McKune System and the Venturi Line Furnace at the South Chicago Works, and the Egler Furnace in use at the Brier Hill Steel Company, Youngstown, Ohio.

McKune System.

The McKune System, originally installed in the Open-Hearth Department of the Steel Company of Canada, Hamilton, Ontario, consists of a volume air blower, which is attached to the reversing valves and furnished air for the furnace at a pressure of six ounces per equare inch.

The air is introduced through the checker chambers into a well and from there through a central port similar to that of a gas producer furnace. This further resembles the modern gas producer furnace in having two outside uptakes and one central uptake leading from the slag pocket, the two outside uptakes uniting in one common opening above the central port. The two outside uptakes, at either end of the furnace, are equipped with water-cooled dampers. These dampers are placed about four feet above the charging floor level, and are operated by a hydraulic manpulating system.

By-product coke oven gas is used as fuel and is introduced in either side of the central port at right angles to the line of the port. The dampers are so arranged as to close the outside uptakes on the incoming end and open them on the outgoing end. Therefore, the air on the incoming end must all rush through the central port under blower pressure, picking up the gas in its travel, which burns with an intensely hot and complete combustion within the first ten feet of the hearth; then there is a slowing down of the products of combustion into the greater volume of the outgoing end, since the outside uptakes on that end are open.

Venturi Line Furnaces.

The Venturi Line Furnaces, as shown in Fig. 3, so called because of the resemblance of the port lines to the lines of the Venturi Meter, were developed at the South Chicago Works, and in a measure along the principles involved in the McKune Type of furnace. They were designed with the idea of obtaining better combustion and flame control with their producer gas fuel. To accomplish this purpose the port area at the entrance of the furnace was greatly decreased by lowering the roof knuckles and moving the monkey or wing walls in, and in this manner a restricted opening for a short distance was obtained, with an easy approach on either side of it. In addition, the mouth of the gas port was placed back about three feet from the point of greatest restriction or neck, thus providing a chamber in which the gas and air could be thoroughly mixed before entering the furnace proper. No fan blowers are used on these furnaces, but all are equipped with waste heat boilers and induced fan draft. This construction has proved successful and has been installed in all their furnaces.

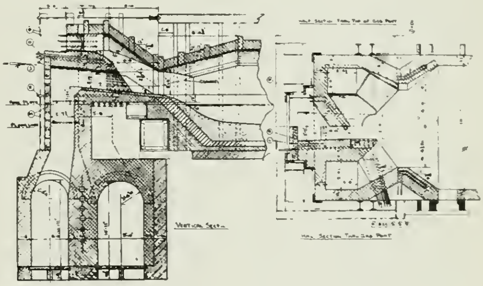


Fig. 3—Venturi line furnace, South Chicago Works, Illinois Steel Company.

A further development of furnace ports is being worked out at this plant by combining the McKune System with the Venturi Line Furnace. Instead of drawing in the monkey or wing walls and thus restricting the outgoing end, as well as the incoming end, a system of water-cooled dampers is installed. These dampers enter the port, one on either side of the gas port, through the roof at the knuckle, or point required for the greatest restriction, thereby taking the place of the wing walls. The dampers are operated so that, the two on the incoming end are in the furnace, while the two on the outgoing end are out of the furnace, thus restricting the flow of the incoming gas and air through a neck with an opening of 13 square feet, and permitting the waste gas to escape through an opening of 31 square feet. The furnace is equipped with a fan which forces in the air used for

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*See F. L. Toy on "The Basic Open-Hearth Process," American Iron and Steel Institute Year Book, 1920, page 345.

combustion as well as being equipped with a waste heat boiler fan which draws out the waste gases. The furnace has been doing wonderful work and has been attracting attention from all sides.

During the month of August, the furnace, which produced an average heat last year of 72.6 tons, operating continuously, made 105 heats of 76.4 tons each, or a production of 8,020 tons. The average time of the heats was 7 hours and 5 minutes, tap to tap, including all delays. It was operated on a charge of 53.2 per cent hot metal, 41.2 per cent scrap and 5.6 per cent metal from the ore. The consumption per gross ton of ingots produced was 400 pounds of coal from the Lynch mine located in eastern Kentucky, of 13,200 Btu value. As this furnace was an experimental one, it was taken off early in September and some changes made in the water-cooled frames of the dampers, as it was felt that there was too much water-cooling exposed to the pre-heated incoming air, and that it tended to unnecessarily cool the air.

The furnace was again put in operation and another run of a month was made, from September 15 to and including October 15, to correspond with the number of days in the previous trial month, using the same charge, and with the same operating conditions. On this run the furnace made 106 heats of 85.5 tons each for a total production of 9,059 tons. The time of heats was 7 hours, 1 minute, tap to tap, and the coal per ton was 348 pounds.

The furnace received the greatest care and attention, and everything possible was done to speed it up, with the idea of finding out what could be done. The steel it produced was made on the regular orders and ranged from .08 to .45 carbon. It is not to be expected that this furnace will do as well working under normal conditions, without special attention, but it should at least show results 70 to 75 per cent as good as those given.

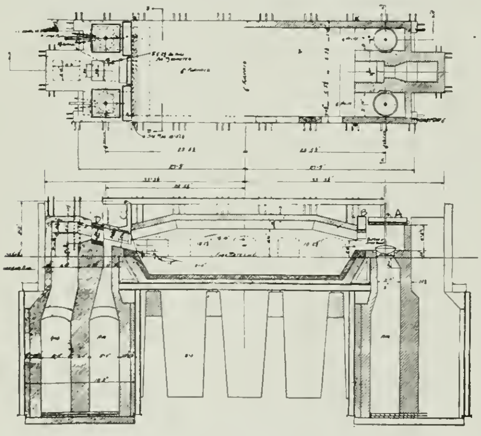

Fig. 4—Egler furnace, The Brier Hill Steel Company, Youngstown, Ohio.

Egler Furnace.

The Egler Furnace, as shown in Fig. 4, was conceived with the idea of making the flame enter the combustion chamber with a blow torch effect. Two of these furnaces, one using producer gas and one natural gas, have been installed in the works of the Brier Hill Steel Company, Youngstown, Ohio.

In order to accomplish the results desired, it was necessary that all the gas and air needed for combustion should pass through a port designed as a combined fuel and air port. In the producer gas furnace the air is forced into the port by fan pressure, and the gas is delivered at the regular producer pressure. The gas comes into the combined gas and air port through the uptake farthest from the furnace and is turned and directed downward toward the hearth in the usual way. At a certain point in its travel through the port, the gas meets a stream of air fed vertically upward and across the stream of gas. The port is so constructed that the air flows around the gas, above and below it. As soon as the gas and air meet, combustion immediately starts, and while the temperature within the port itself is not unduly high, combustion is complete by the time the flame has reached the middle door of the furnace. In the natural gas furnace, the air, the combined gas and air port through the uptake which is used for gas on the producer gas furnace. The natural gas is admitted through pipes at a point between the air uptake and port outlet to the furnace.

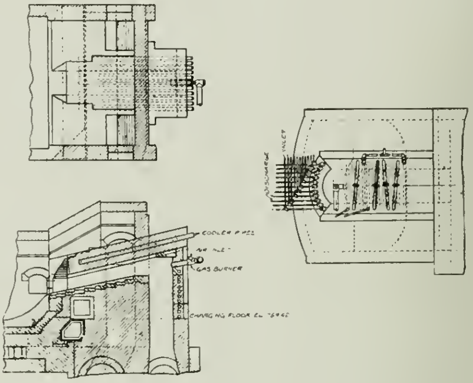

Fig. 5—Showing by-product gas burner installed in end of producer gas furnace at Duquesne, Works.

At each end of the furnace are two flues, auxiliary to the main gas and air uptakes. These flues at the upper end are fitted with water-cooled mushroom valves on water-cooled seats. On the incoming end the valves are closed and no air can enter the furnace through these flues, all air being forced to enter through the combined gas and air port. On the outgoing end the mushroom valves are open, permitting the waste gas free passage out of the furnace through all the flues.

Both of these furnaces have been operating for some time and are giving good results, 75-ton heats being made in an average of 7½ hours, with a fuel practice of approximately 400 pounds of coal per ton of steel on the producer gas furnace, and 3,700 cubic feet of gas per ton on the natural gas furnace.

Burning By-Product Gas With a Luminous Flame.

The burning of by-product gas in an open-hearth furnace has always given more or less trouble, because of the difficulty of keeping the flame down on the bath; and from the fact that it burns with a non-luminous flame, it was difficult for the furnaceman to know what he was doing. It has been the general practice to use tar in amounts dictated by experience for the purpose of giving luminosity to the flame. The usual procedure was to blow a jet of tar, atomized by air or steam, through the port, immediately over the incoming gas.

During the year 1918 a gas line was completed connecting the by-product coke plant of the Carnegie Steel Company, located at Clairton, Pa., with the Duquesne Steel Works, to supply the latter with coke oven gas as a substitute for natural gas. After this gas was made available, many experiments were required to effect its satisfactory substitution. The object of the experiments was to obtain, without the introduction of tar, the elementary principles of natural gas, namely, luminosity and a non-oxidizing atmosphere when necessary.

In the open-hearth practice, it was found that by the introduction of a small quantity of air in the burner, forming a primary combustion at that point, a luminous flame could be obtained in the furnace. It was also found that by varying the quantity of air introduced in the burner, full control of the flame from non-luminous to densely luminous was possible. For the secondary combustion, the required air was brought in through the ports in the regular manner.

The Duquesne Works has thirty-two producer gas fired open-hearth furnaces, each two connected to the gas producers by a single underground flue. Although the flues were burned out regularly every week end, a deposit accumulated in the underground flue, which had to be removed periodically by hand. This necessitated shutting down the two furnaces connected to the flue, which resulted in a considerable loss of tonnage.

To overcome this loss, all furnaces were equipped, as shown in Fig. 5, to burn by-product gas during the cleaning period, and all furnace crews have been required to burn this fuel, which they have done successfully and with good fuel practice.

The time of changing from one gas to the other ranges from fifteen to thirty minutes, and except for the introduction of the burner and admitting air through both the gas and air ports, when burning by-product gas, there is no change in the operation of the furnace.

At times when the gas supply was plentiful, the furnaces have been operated with it for varying periods, one furnace making a run of 55 heats, producing 3,044 tons of steel, with a fuel practice of 9,574 cubic feet per ton.

In conclusion, it may be stated that while progress has been made in the last decade in improving the design of the open-hearth furnace, the result being larger furnaces, increased life and a decreased fuel consumption, yet the field for further improvement is large and every open-hearth superintendent and engineer should be on the alert to introduce such changes in design and practice that will tend to a more efficient burning of the fuel.

Steel Lumber and Its Application

Simplified Examples of the Use of Steel Lumber—The Possibility of Steel Replacing Wood in Building Construction

By THOMAS J. FOSTER
Chairman, National Bridge Works, Long Island City, N. Y.

THE good qualities of wood as a building material, the ease with which it could be secured in all parts of our country, and the convenience of handling have made it hard to replace, especially in the building of floors and partitions. Wooden joists make light supports and are conveniently spaced for the fastening of the lath for the ceiling and for the rough flooring. If wood were fireproof and did not shrink, it would be the ideal building material, but the lack of these two qualities, coupled with the fact that it is getting scarce, must drive it out of the building material market in our thickly populated communities. The fire hazard in our cities is too great to permit the use of wood except under certain restrictions; and as the population of our cities increases, the greater will be the need for having all construction fireproof. The growing scarcity of wood and the increasing need of fireproofing will develop constructions that will make it uneconomical in our cities to build of combustible materials.

In looking for the ideal material for floors we should keep all the good qualities of the wood floor and eliminate the bad ones. In the earliest types of fireproof floors, fireproofing materials were so little known that only crude floors made of brick arches, or heavy concrete arches between iron beams, were used. The result was expensive and the necessity of having fireproof buildings brought out better designs as shown by the flat tile arch supported by steel beams. Arches finally gave way to flat slabs of concrete supported by steel or reinforced concrete beams. This construction did not give a flat ceiling except at an extra expense, and consequently many hotels and apartment houses have the beams projecting into the rooms. None of these types had the good qualities of wood construction. They required wooden forms for putting the material in place. Some of them took as much wood as was necessary to build the floor only to have it all torn out. All of them were too heavy. Economy calls for the building of a floor with no waste materials in its construction. Fig. 1 shows a comparison of the weight per square foot of various fireproof floor constructions worked out for the same loading and span.

Paper presented before American Iron and Steel Institute November 18, 1921, New York City.

Steel lumber consists of light structural steel members in the form of I-beams and channels of approximately one-third the weight of the standard sections of equal depth, and primarily designed to fulfill the functions of wooden joists and studs. The manner in which I-beam sections are made from channels by riveting or spot-welding and the method of attaching metal lath are shown in Fig. 2.

The adaptability of this material soon secured it a position in the various types of fireproof construction, and today you will find these sections installed in office buildings, hotels, schools, apartments, light factories, light warehouses, theaters, garages and residences.

In the year 1901 the first small sections and in 1907 the first steel lumber joist sections were made of sheet steel. The sheets were slit and formed into channel sections on brakes. The I-sections were formed by placing two channel sections back to back and riveting them (see Fig. 2). Lengths greater than 16 ft. 8 in. were made by splicing. The first installation was made in a two-family Tuxedo Park Association. The entire frame of the building including the joists, studs and rafters was made of this material. Metal lath was attached to the studs as a base for the stucco on the exterior and for the plaster on the interior. Metal lath was also placed over the tops of the joists which formed a support and furnished reinforcing for a two-inch concrete slab. Wooden nailing strips were fastened to the steel lumber joists and embedded in the concrete as a base for the wood floors. Metal lath was attached to the bottom of the steel joists to support the plaster ceiling. This was the first time a fireproof construction was used having the good qualities of wood construction. It was built by the Taft-Howell Company of Cornwall-on-the-Hudson.

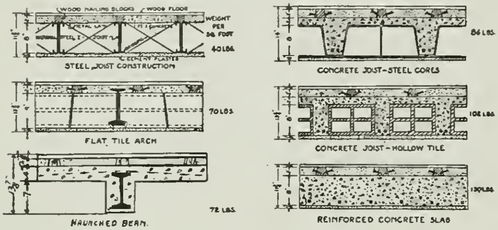

Fig. 1—Comparison of the weight per square foot of various fireproof floor constructions. Note the light weight (40 pounds) of steel lumber construction.

The present method of producing steel lumber was started in 1919. The finished strips are made from slabs in a single mill. These slabs are from 8 in. to 16 in. wide by 3½ in. thick and weigh from 300 to 700 pounds each. A specially designed hot strip mill takes these slabs down gradually to strips of .072 inches to .102 inches gauge and widths up to 17 inches. The strips are made 130 feet long, finished hot and coiled. The coils, when cold, are fed into forming mills which produce the steel lumber channel sections. I-sections are made by placing two channel sections back to back and passing them through automatic spot-welders. Two rows of welds ⅜ in. diameter are staggered along the web of the section. The ends are trimmed and the pieces cut to length by high-speed friction saws. The steel lumber is piled for convenience in handling and is then dipped in a large vat of special paint. This insures the paint getting to every portion of the steel. The painting is for protection until the steel lumber joists are installed in the building. After they are in place and the building completed, as in all buildings, conditions that cause corrosion do not exist.

In one mill producing these sections, having a capacity of 8,000 tons per month, the steel used is of standard analysis, carbon content of from .16 to .24. Phosphorus and sulphur are held under .04 and manganese under .35. This relatively high carbon content, together with the method of working the material, gives a uniformly high ultimate strength. The material from this mill will show an average ultimate strength exceeding 72,000 lbs. per square inch, compared to 60,000 lbs. per square inch for the rolled sections.

The channel sections are furnished only up to 6-inch depth and are used for studs in partitions. The joists are furnished in 4-in., 5-in., 6-in., 7-in., 8-in., 9-in., 11-in. and 12-in. depths. The flange widths are designed to secure the best working stresses in all parts of the section. The 4-in., 5-in. and 6-in. joists are 3 in. wide; the 7-in. section 3½ in. wide; the 8-in. and 9-in. sections, 4 in. wide; and the larger sections are 4½ in. wide.

While the steel lumber joists, spaced 16 in. to 24 in. center, will require a little more steel than is used ordinarily for the steel beams in some types of floors, yet the dead weight of the floor being only about 40 lbs. per sq. ft. instead of 80 lbs. or more as required in some other types of fireproof floors, requires less steel in the girders and columns, and less material in the foundations. Economy in the use of steel lumber results from the following causes:

(1) The distribution of the steel requires less of other materials, eliminating their cost and the cost of carrying them.

(2) All of the material used in steel lumber construction is a part of the permanent structure, and only enough material is used to give strength and rigidity.

(3) Less labor is used in producing the structure, as less material is put up, and there is none to come down and be carted away from the building.

(4) It requires less time for construction. This results in getting the building ready in a shorter time for business or for the collection of rents, and cuts down the interest accruing on the investment in the land.

(5) The cost of insurance and of maintenance is less in the steel lumber construction than in wood. In some cases these reductions will make the cost of the fireproof structure as cheap as the wooden structure after a period of ten years, and it will be a better and longer lived building.

The steel industry should be capable, by producing better shapes of the steel lumber type with the cheapness due to quantity production, of lessening the economic loss due to fires. The National Board of Fire Underwriters gives the losses due to fires in the United States for the five years previous to 1921 as $1,416,000,000. This figure is the adjusted fire losses with 25 per cent added for unreported fires and those occurring in uninsured properties. For the total economic loss you must add to these figures all the incidental losses, which sometimes amount to as much as the fire losses themselves.

The same authority says that "over 90 per cent of our school buildings are potential death traps.". "Figures compiled by the National Board of Fire Underwriters through its Actuarial Bureau show that in 1918, the last year of completed statistics, there were on the average nearly five school fires for every day of the 365 days, or a total of 1778 fires for the year."

The fire resisting quality of a floor is of the greatest importance and in the first attempts at fireproofing a large quantity of material was looked upon as necessary. Experiments as well as actual fires have shown that it is largely the ability of the incombustible fireproofing materials to expand and contract satisfactorily which makes a good fireproofing material. From the study of the Baltimore and San Francisco fires it is shown that cement plaster on metal lath stood the fire better than the heavier materials, for instance, tile.

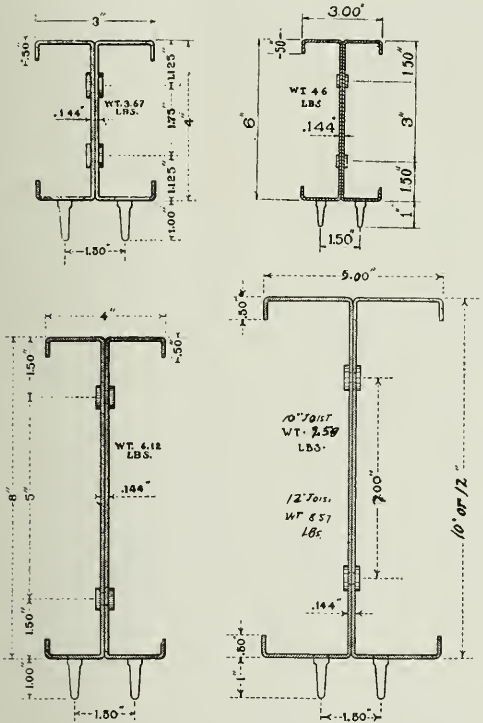

Fig. 2—I-beam sections made from channels, showing prongs punched out of flange to engage metal lath. The channels are here shown riveted.

Tests were made of steel lumber construction by the City of New York on April 14-15, 1915. A floor designed for 150 lbs. per sq. ft. live load was erected over a furnace and loaded to 150 lbs. per sq. ft. with pig iron, and a temperature of 1,700 deg. F. was kept up for four hours. A stream of water was then played on the ceiling and there was practically no damage by fire or water. The next day after the fire the floor was loaded to 600 lbs. per sq. ft. and after such loading had a deflection that was not excessive.

Floors as usually constructed are composed of a large quantity of material and subject to bad cracks, no doubt caused by uneveness of expansion and contraction. Steel lumber floors show no cracks. The steel can always be depended on to do its work properly, and the two inches of concrete on top of the steel with the embedded metal lath will prevent any uneveness of expansion and contraction. The ceiling is also protected against cracking by the metal lath and cement plaster, forming a uniform material over the entire surface.

No change has been made from the original method of installation of steel lumber floor. The steel lumber is put in as joists from 16 in. to 24 in. centers. Metal bridging is used between the joists. Metal lath is stretched over the joists and wooden nailing-strips are fastened to the joists through the metal lath. Cinder concrete or other fireproof material is filled in on top of the metal lath and between the wooden strips. For the ceiling the lath is fastened by clips to the lower flanges of the joists and cement plaster is used on the lath (see Fig. 3).

Steel lumber was not produced on a tonnage basis until 1919, and its value has been recognized, as shown by the fact that 30 million square feet of this construction has already been installed throughout the country.

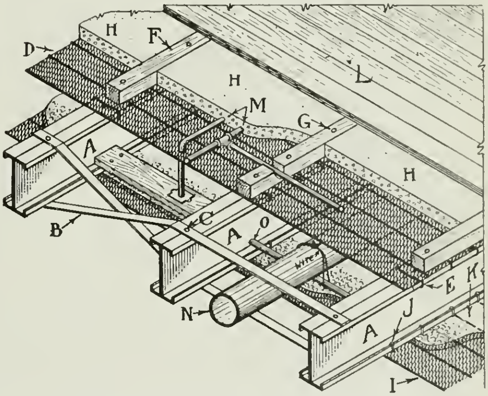

Fig. 3—Isometric drawing showing steel lumber floor construction. A—steel lumber I-joist. B—Metal cross bridging. C—6-d. nail for securing bridging to steel I-joist. D—Metal lath for top of steel I-joist. E —Spring clips for securing lath to top of steel I-joists, clips to be spaced about 8 in. centers. F—1¾x1¾ in. wood nailing strips. G—12-d nail for securing wood strips to tops of steel I-Joist, nails to be spaced 18 in. to 20 in. centers. H—Concrete fill. I—Metal lath for ceiling. J—Spring clips for securing metal lath to bottom of steel I-joist, clips to be spaced 6 in. centers. K—Plaster. L—Wood finish floor. M—Water pipes and electric conduits. N—Soil pipe. O—Small pipe resting on bottom flanges of steel I-joists to support soil pipe.

The steel lumber type of floor, as shown by the isometric drawing (see Fig. 3) is ideal. Each part is made of material whose strength is a certainty, no more material is used than is actually required, and no material is used that is not a part of the finished structure.

The steel lumber section itself is not ideal; too much of the weight is in the web. This objection is partly met in the sections showing the angles spot-welded to the web, but it has the disadvantage of being made up of five separate pieces. This floor construction is in its infancy and we expect to see some engineer solve the problem of producing an "I" section of light material that will have the right proportion of web and flange. Theoretically, this should give a section weighing not more than 70 per cent. of the present section and with a carrying capacity greater than the present section, making the theoretical section 50 per cent more efficient than at present. This is not impossible.

Residence work, including apartments, is 20 per cent of the total building of this country. The majority of this is furnished by so-called speculative builders. The houses are built to sell. No dollars will be put in on which quick returns cannot be made, but with an ideal steel joist, that can be installed as cheaply as wood, the tide will be turned and a large share of these wooden structures will be built of steel. The buildings now being erected with fireproof materials will be materially reduced in price by using the steel joist type of floor, the amount depending on various conditions, such as the use of the building, the load to be carried, and the location of the building. This will call, not only for a large quantity of joists, but the joists will require rolled beams, and they will require steel columns. Thus the entire steel industry will receive an impetus and those occupying buildings, whether for residence, for business, for church or for schools, will have the benefit of cheaper occupancy and, for all of them, an occupancy safe from fire.

Fusion Welding in Steel Plants

Fusion Welding Is Performed by Actually Melting Together the Pieces to Be Joined by the Application of a Very Local But Very Intense Heat

By S. W. MILLER
President American Welding Society

I HAVE been asked to present for your consideration a paper on the subject of fusion welding. These processes, for there are several of them that may properly be included in the term "fusion welding," are in their present applications of comparatively recent origin.

The term "welding," as used before the introduction of fusion welding methods, was well understood to apply only to wrought iron and steel and the operation was performed by bringing two or more pieces of these metals to a pasty condition by means of heat and then forcing them together either by hammering, pressing or some other mechanical means. Fusion welding, as the term implies, is performed by actually melting together the pieces to be joined by the application of a very local but very intense heat, so that only a small part of the pieces to be joined is brought to the melting point. It is not only not necessary but it is undesirable to force together the pieces when these processes are used, so that fusion welding is radically different from welding as formerly understood and applied. A further point of difference is that fusion welding is applicable to all metals. The oldest instance of fusion welding is lead burning, which has been in use for many years.

Processes of Fusion Welding.

The processes of fusion welding in use at the present time depend for their sources of heat on three reactions:

First: The burning in the presence of commercially pure oxygen of a combustible gas; acetylene is the one most frequently employed, although hydrogen, city gas and others have been successfully used.

Second: The electric current.

Third: The thermit reaction.

The first process, in its widest commercial application, makes use of acetylene as the combustible gas because it produces the highest flame temperature known, probably about 5,500 deg. F. This is by reason of its very large carbon content, 92.3 per cent.

The second process may be utilized in two principal ways: First, by striking an arc between the piece to be welded, which is attached to one terminal of the circuit, and a rod of carbon or graphite connected with the other terminal. The maintaining of the arc produces an intense heat which melts the metal; necessary additional metal can be provided to fill cavities, etc., by holding in the arc a rod which is melted into the cavity. Second, by striking an arc between the piece to be welded and an electrode of metal, which on account of the heat of the arc is melted into the piece being welded, thus filling up the cavity or joining the pieces of metal together.

The thermit reaction is based on the fact that aluminum has a much stronger affinity for oxygen than most of the other metals, so that if powdered aluminum is mixed with a metallic oxide, such as iron oxide, and the mass be brought to a high temperature at one point by means of a red hot piece of iron, for example, the aluminum will combine with the oxygen of the oxide, setting free metallic iron. The reaction is propagated automatically through the mixture with the result that aluminum oxide floats on top of the melted metal, which can be poured into a mold or otherwise utilized. In practice, the ends of the pieces to be joined are brought to a high temperature in the mold surrounding them, into which is poured the thermit metal, which fuses into the pieces to be joined, making a solid fused joint.

The oxyacetylene process, or as it is frequently called, gas welding, is applicable to more metals and more conditions than either of the other processes. It is limited in its application chiefly because it is difficult for practical reasons to use it on very large sections of steel, although it has been applied under suitable conditions and with suitable precautions to such large sections. Its

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Abstract of paper presented before American Iron & Steel Institute, New York, November 18, 1921.

cost is high in the case of large pieces compared with the other processes, because of the high cost of gases, but the tanks in which the gases are compressed and the rest of the apparatus are easily portable, making it very easy to take to the work. The electric arc processes are in some respects more difficult of application because of the necessity of protecting the operator from the effect of the ultra-violet and infra-red rays of the arc, as well as from its intense glare and heat, so that the operator must wear gloves, masks and clothing that will prevent these rays from reaching the skin. In hot weather these precautions are oppressive, particularly in the case of the carbon arc. The precautions necessary in the case of acetylene welding are not so great, as the dangerous rays referred to are present in only a small degree and proper goggles are all that is necessary to protect the eyes from the glare.

For carbon arc welding a current as high as 1,000 amperes at from 60 to 75 volts may be used, whereas a current of less than 300 amperes is of but little value. Under these conditions, some care must be taken to protect the operator against the current, and wet gloves or shoes may be more or less dangerous. With the metallic arc, a current as high as 200 amperes may be required with an arc voltage of from 18 to 20. The temperature of the positive crater of the carbon arc is about 6,300 deg. F., but, so far as I know, the temperature of a metallic arc has never been determined; it is, however, very high and much more local than that of the oxyacetylene flame. The carbon arc process is usually confined to filling cavities in steel castings, although it has been used with great success in some cases for other purposes. It is not, however, as popular as the metallic arc, although the latter is confined for most practical purposes to the uniting of steel and wrought iron. The thermit process is of particular value for the welding of large sections of steel, and has proven of inestimable worth in the repair of such parts as stern frames and rudder frames of steamships, many notable instances of which could be cited. The temperature of the melted thermit steel is probably about 5,000 deg. F. It is not possible to state any fixed limits to the application of the various fusion welding methods. Under some conditions the acetylene process would be better for the same job than the electric or the thermit, and vice versa. In many large plants acetylene and electric welding are interchangeably used and with equally good results, so that it is quite futile to make any statement as to their relative merits in this direction.

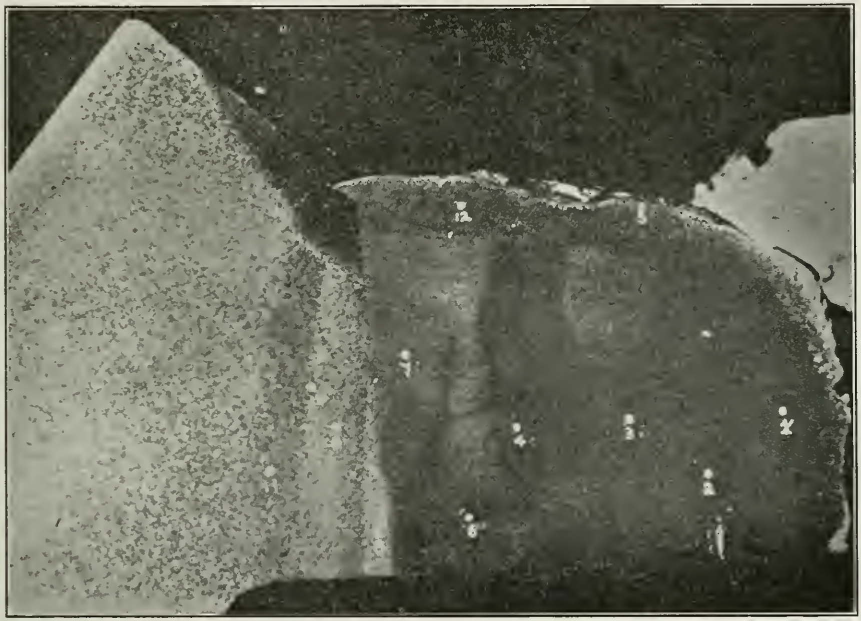
Fig. 1—Electric weld made with covered electrode. The microscope shows different structures at each of the numbered spots. It is usual to find widely different structures in different parts of a weld, especially if it is a heavy piece.

As thermit welding is usually applied only to large sections of steel, and as these applications are neither as numerous nor as various as those of the other two methods, it will be well to give more attention in the present paper to these latter than to the former.

Fusion Welding Practice.

Success in the use of either process depends on several things, but principally on restricting their application so that impossible or dangerous jobs shall not be attempted. It is quite natural for an enthusiast in welding to apply his pet process to everything in the hope that it will be successful, but from a standpoint of safety the enthusiast should be restrained from doing things that fundamentally are incorrect. Unfortunately, we are not in a position to state positively what are the fundamental principles and practices of welding, although much progress has been made in successful applications. A consideration of what actually occurs during welding, as far as it is known, may be of assistance in enabling us to determine how far we should go in using these processes.

In the first place, fusion welding is simply the making of a casting of whatever metal is being welded. The conditions which will permit of sound castings being obtained in the foundry are fairly well known. The melted metal must be protected from oxidation, and care must be taken to prevent cold shuts and other defects. The metal must not be overheated and a proper alloy must be used if good castings are to be obtained. Other precautions will naturally suggest themselves to those familiar with foundry practice. In fusion welding, the conditions for the making of a good casting are largely absent. The melted metal is exposed to the air with chances of becoming oxidized or absorbing gases. It is very easy to produce laps and cold shuts; metal is easily overheated and the constituents such as carbon, zinc, tin, etc., are readily removed; also as the weld is a casting it has all the defects of a casting, even when of the best quality. It is coarse grained, has low elongation and has comparatively little resistance to alternating stress and shock, so that when two pieces of forged metal are united by welding, it cannot be expected that the same results, either physical or chemical, may be obtained in the welded piece as existed in the forged piece. Again, any heat treatment to which the piece had been subjected is destroyed for a certain distance from the weld by the heat; and again, a metal so affected cannot be equal to that which has not been heated. In view of the above facts, it is evident that for safety and success, the maker and user of welded parts should use good judgment in the application of the processes.

You are particularly interested in iron and steel and the consideration of welding of all metals would take more time than is at my disposal. I feel it would be well to confine our attention to the welding of iron and steel, first, in a general way, and second, with regard to a few specific points which may be of special interest to you.

Fusion Welding of Cast Iron.

The welding of cast iron is easier than that of any other metal, and the results obtained are better, except possibly in case of cast aluminum, where the results are just as good. In welding cast iron, any material that is to be added should be of such a character that the application of heat will not burn out the carbon and silicon to such an extent as to make the weld difficult to machine. This means that it should contain a considerable proportion of silicon, this being the first constituent to disappear under the heat. Ordinary machine iron is entirely unsuitable for the purpose, and it is usual for a good cast iron welding rod to contain at least 3 per cent of silicon. When this metal is melted into the weld, it produces a fine-grained structure lower in graphitic carbon than the material being welded, because it is applied in small quantities and cools rapidly. A properly welded piece of cast iron will always break outside the weld. The principal difficulty in cast iron welding is in taking care of the shrinkage or contraction, which of course cannot be avoided, although it can usually be allowed for by expanding other parts of the piece, or by setting the pieces farther apart than they were when broken. The proper methods to follow to avoid strain in the welded piece, due to expansion and contraction, require close attention and much experience on the part of the welder; and even with the greatest care cracks occur at times. It is quite possible that there will be heavy strain in the welded piece, which, however, will not be great enough to cause trouble until it is put in service, when the additional strain due to this may cause it to break. Chilled iron is readily welded, although, on account of its brittleness, the difficulties from expansion and contraction strains are increased when compared with grey iron. Malleable castings dare not be melted, and therefore are not capable of being welded, unless they can be annealed, which is usually impossible. It is therefore customary to join broken parts of malleable iron by using a manganese brass, or a similar alloy, which will unite with the malleable iron at a temperature below its melting point. The joint so made is strong and ductile and answers every purpose. Of course, if the malleable iron be melted, it will revert to chilled iron and lose its strength and ductility. Even the use of manganese brass will to some extent change these properties, but not sufficiently to cause trouble in practice.

Fusion Welding of Steel.

Fusion welding of cast steel is done in many instances as repair work in the steel foundries; and if properly done the results are entirely satisfactory. This is of course largely because the piece being welded is a steel casting, as is the weld. Welding of forged steel in the shape of plates, sheets, bars and shapes is done to a very great extent, especially in manufacturing. Such products as barrels, range boilers, pressure vessels of all kinds, steel tubing and many other products which will occur to you, are made in large quantities with entire satisfaction by fusion methods. Steel is the most difficult metal to weld and with some varieties I do not believe it is possible by any fusion process to get results that are more than moderately good. It is not common to attempt to weld steel of higher carbon content than about .25 per cent and it is not wise in my opinion to place any dependence on welds made in high carbon steel. The lower the carbon content the better the results, and the welding of structural steel changes its physical characteristics so much that great care should be taken to allow for the change if any great strain comes on a piece. The difficulties in welding steel are the same as those encountered in welding other metals, but are aggravated by the high melting point, the rapid solidification and the great change in the structure and physical properties of the metal due to the high temperature to which it is subjected during the welding process, as well as to the fact referred to before that a weld is only a casting. We all know that the lower the carbon in steel the more severe treatment it will stand, either mechanical or by heat. For instance, a piece of soft flange steel may be quenched from a high temperature, may be cold worked by bending and may be forged through a much wider range of temperature than a piece of tool steel. In other words, the former is much more rugged than the latter. Now, in welding, particularly with long seams or irregular shapes, there are introduced all of the elements of distortion and overheating which seriously injure high carbon steel. It is therefore evident that it is wise to confine ourselves to the use of as low carbon steel for welding purposes as is possible, and practice confirms this opinion.

The best steel for welding and one which is commercially available at reasonable cost is probably of about the following composition: Carbon .15 per cent maximum; manganese .30 to .60; sulphur not over .05; phosphorus not over .04.

Its physical characteristics will be about 50,000 pounds tensile strength, yield point about 30,000 pounds per square inch and elongation at least 30 per cent in 8 inches. Of course, such material is not suitable for structural steel, but for pressure vessels it is advisable as will be explained more fully later. The ideal weld would be one in which the structure and the chemical and physical properties were identical with the piece being welded; it is evidently impossible to obtain this in any case regardless of the processes used or of the welding wire employed. We are therefore restricted to either one of two courses; we must either make the weld stronger than the piece being welded, or we must assume or find by experimenting the efficiency of the weld when it is weaker than the pieces being welded. The weakness of a weld may not, however, depend entirely on its tensile strength. This may be higher than that of the pieces being welded and still the weld may be weaker in its resistance to alternating stress or shock. These latter stresses are the ones to which welds are least resistant, so that, even if the tensile strength of a weld is equal to that of the base metal, the weld may be much weaker when stressed in any other way than by pure tension; for instance, in a boiler or pressure vessel where the stress is alternating, in the steering knuckle of an automobile, or in its frame. Evidently, also the design of a welded piece may be bad, if the weld be made in a place where it is subjected to these injurious stresses, while it might be perfectly safe if the weld were made somewhere else. As an illustration of this, a head should never be welded in a tank with the weld at the junction of the shell and a flat head, if it is to stand any great pressure In riveted construction, it is not possible to avoid flanging of either the head or the shell, but in welding it is simple to design the tank as referred to, that it is quite common practice to make them in this way. The bending stresses at the weld will, however, in the course of time cause it to crack, especially if the head be unbraced. These and similar designs should be avoided because of the peculiarities of welds.

Stresses in welded structures are of course due to the heat of the welding process, and in the case of rigid material where the welded seams are long, these stresses must be largely concentrated in or near the weld. If the weld is not strong enough to resist them, it will break; if it is strong enough, the stresses will be there, as they are in cold rolled or other cold worked material. Such stresses sometimes exist in welded seams until they are subjected to shock such as a blow of a sledge, when the additional stress will cause a rupture. On the other hand, if the base material is not rigid, but very ductile, the stresses will be distributed through it to a greater distance fro mthe weld, so that the stress per square inch is reduced below the danger point. This is especially true if the weld metal is much stronger and stiffer than the base metal, and in my opinion this is the proper way to design vessels or structures subjected to heavy stresses.

Welding Metal for Fusion Welds.

Considering the welding metal to be used, it is obvious that no more than a certain strength and resistance to stresses can be obtained with any given material, even with the best workmanship, and if greater strength or resistance be desired, the weld metal must be altered in character. There is, of course, a limit to this, because with steel, as the tensile strength becomes higher, its resistance to shock becomes less, unless it be heat treated, which is not possible commercially in the case of welded structures. So that dependence must be placed on the character of the metal in the weld without heat treatment. The usual material for gas welding steel is a straight low carbon steel wire of about the following composition: Carbon .06 to .10 per cent, manganese .15; sulphur .03 and phosphorus .03. In other words, it is a very pure low carbon steel. Evidently, the strength in a weld made with this material will be low, and it is found to be about 52,000 pounds per square inch in one-half inch plate. It is clear that if this material be used to weld standard boiler or fire-box steel having a specification strength of from 55,000 to 65,000 pounds, the weld will be weaker than the plate. How much weaker depends on the quality of the weld, which if defective may be very weak, so that it has been customary in the past to speak much of the efficiency of a weld. These efficiencies have been found to range in actual tests from 36 to 80 per cent, varying with conditions and the quality of the weld. It is also evident that if such a weld having 52,000 pounds tensile strength were made in a plate of 50,000 pounds tensile strength, the plate itself would break outside of the weld. In view of the possible defects in welds, due to careless or inefficient welders, or to variations in the strength of the plate, this margin of 2,000 pounds per square inch is not sufficient in my opinion, and a stronger welding metal should be used. Such a metal is found in nickel steel of approximately the following composition, which corresponds to the Society of Automotive Engineers' specification N. 2320: Carbon .20 per cent; manganese, .40 to .60; sulphur, not over .04; nickel, 3.25 to 3.75. This metal gives in the weld about 58,000 pounds tensile strength, although it has less ductility than the weld metal above referred to. However, its margin of strength above 50,000 punds plate is sufficient to throw the strain into the plate because of the latter's ductility, so that the weld itself is not stressed beyond a safe point.

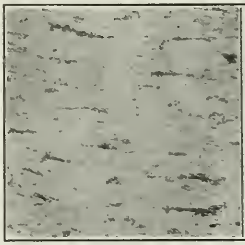

Fig. 2—Electric welding wire, about .15 carbon. Grains are elongated, due to cold drawing, which is necessary for electric welding wire. x200.

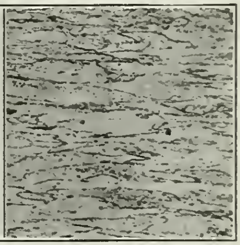

Fig. 3—Armco electric welding wire. Cold drawn. x200.

The strength of the welds given above are for equal sections with the plate, and as it is customary to reinforce welds by increasing their thickness, say 10 per cent or 15 per cent, the strength of the weld is still more per square inch of plate section than the figures given. Economy, however, requires that the weld be reinforced no more than necessary, so that it is still advisable to use some such material as nickel steel in the weld.

Reference has been made to the face that welds are usually over-oxidized castings, and a steel weld is no exception, but it appears that in the case of nickel steel welds the oxidizing is much less. This seems to be due to the formation during welding of a tough, viscous slag, which is probably due to the formation of nickel oxide. This coating on the weld is very thin, but seems to be sufficient to largely protect the metal from the action of the air. Whatever the cause may be, the microstructure of the weld shows it to be much more free from ferrous oxide than ordinary weld metal. It is not necessary that nickel steel be used. Any material will answer that will give equal results. But nickel steel is readily obtainable and, until other alloys are found, I feel that nickel steel should be used for important work.

For electric metallic arc welding a usual composition of welding wire is as follows: Carbon, .15 to .18 per cent; manganese, .40 to .60; sulphur, not over .04; phosphorus not over .04. The exact chemical composition is of much less importance than are uniformity and high general quality. Gas welding wire may be of any reasonable hardness, though it is usually quite soft; but for electric welding the wire must be hard drawn to just the right amount ,or it will not work well. It is only too common to find that part of a shipment sputters and splashes, and will not fuse quietly with the base metal, or that one shipment will be good and another bad. I am inclined to think that this is largely due to the general quality of the wire. That is, its greater or less freedom from non-metallic impurities, frequently called sonims, and from gases and similar impurities, but the real cause will not be known until just what occurs in the arc is fully determined, which will require much careful and accurate research. The welds made with this material may have a tensile strength of up to 60,000 pounds per square inch. Their elongation is less than that of gas welds and their resistance to shock is less.

Quality of the Base Metal.

It is just as necessary to have high quality in the base metal as in the welding rod. And as this is a matter about which but little has been said, I would like to enlarge somewhat on it.

I might say at the beginning that I have never found a bad welding steel that was not full of sonims, nor a good welding steel that was not free from them, except in one or two instances. I believe it is possible to make a bad welding steel by improperly annealing good material, especially in sheet, where the effect of an oxidizing atmosphere is much greater in proportion than in plate, because of the thinness. The effect is to make the material brittle, presumably by allowing the oxygen to penetrate the grain boundaries, being in effect an incipient burning. It has been shown that by heating in a reducing atmosphere at a temperature below the Ac.1 point, the brittleness was removed, which would seem to show that oxide films at the grain boundaries caused the trouble.

Therefore it seems reasonable that careful attention should be paid to the quality of the steel from the time of the selection of the raw materials, through the furnace processes, during the rolling, and finally while it is being annealed.

The nature of the non-metallic impurities that cause trouble in welding I am not sure of, because they are usually very small, but as the metal just round them seems to be porous to a greater or less extent, it would seem that they must be oxides or silicates. It is also quite probable that the porous part is filled with gases, because bad welding material spits when it is heated to the welding point, indicating that gas has been formed in some way. It is also noticeable that in preparing a specimen for the microscope the later grindings, if done on soft cloth, remove the material around the sonims and give the unetched section the appearance of being spotted with a lot of comet tails, which of course are much larger than the actual size of the particles of impurities. I think it is perfectly safe to say that the microscope will always determine whether a steel will weld properly, exept where it has been put through an annealing process which would damage it at the grain boundaries. I also feel that chemical analysis shows nothing of the welding qualities within wide limits, unless the steel is badly off.

The Skill of the Welder.

Even assuming that steel of good welding quality and good welding material is used, there is always present the question of the ability and skill of the operator. This is true regardless of the process used. While the skill of the operator in any mechanical process is of importance, in welding it is of far more moment, because his work cannot be inspected in any way known at the present time, so that not only his skill but his honesty must be beyond suspicion. It is therefore advisable to have each operator weld test pieces of the size that is suitable to his work and have them tested at regular intervals. In many cases the operator himself does not know what he is doing and the testing of his work will spur him on to do better, if he is the right kind of a man, and others should not be employed on important work.

Much has been said and written about the training of operators, and it is too common a belief that a good welder can be made in from six weeks to three months. It is indeed true that for certain classes of work, such as the welding of sheet steel, the work can be taught to an intelligent man in a short time, provided he receives proper instruction, and it is also true that the time required to absorb a given amount of knowledge will vary with different men, but to enable a man to have a thorough knowledge of welding steel, much longer experience than three months is necessary. There is no process that I know of that looks so easy, and yet is so difficult, to do right as welding steel plates. It is really an art and not a mechanical process. As with all artists, welders may use different methods and still arrive at the same result, a weld free from mechanical imperfections. So that a discussion of welding methods is more or less futile, the only real requirement being a thorough welding of the base metal and the weld metal together. All of these subjects, in both general and specific applications, are being considered by committees of the American Bureau of Welding, which is affiliated through the American Welding Society with the National Research Council, by virtue of its committees being also the same committees of the last mentioned body.

The Cause of Failure.

One of the matters which is of vital interest to all those using welding processes is the cause of failures in welded parts. While there has been no systematic investigation of such accidents, it is probable that those which have caused the most trouble have been in the case of welded pressure vessels, and as these are usually made of steel the subject should be of interest to you. It has been stated before that it is essential in welding by any process to get a thorough union between the weld metal and the base metal, and that it is necessary that the weld be sound. Given good operators and proper welding material, there is no difficulty in obtaining the desired result, but it is of just as much interest to know how results are obtainable, and why welds fail, as it is to know how to make good steel, and why steel sometimes fails. The microscope shows better than any other instrument the nature of the defects in welds, and when this is known, and not until then, precautions can be taken to avoid them. Generally speaking there are two avoidable effects which are in reality one: first, lack of fusion along the side of the V, and second, the lack of fusion in the weld metal itself. The tendency in welding steel is to underheat the plate because it is much heavier in section than the welding wire, in which case the melted wire may fall into the V without being fused to it. The same thing may happen in the weld. When this occurs there is a thin film of oxide between the two layers of metal, and this of course destroys the strength of the piece. In addition to this there is the oxidizing action of the water vapor in the gas welding flame and that of the air on the finely divided metal passing through the electric arc. If the gas welding flame be not properly adjusted, or if the torch be of poor design, there is the additional possibility of free oxygen being present and causing serious trouble. An improperly made weld will show streaks of oxide or other impurities which are frequently very small and thin, and yet the first evidence of distortion of such a weld is at these defects, just as the first evidence of distortion in a piece of steel is at similar defects. During the welding operation these defects appear as bright white spots or streaks in the case of gas welding, which can be floated to the surface and removed. In the case of electric welding this is not possible, except to a limited extent, because whatever impurity is in the electrode must go into the weld. The films or streaks referred to are frequently clearly visible under the microscope, but many times rupture occurs at the grain boundaries in both gas and electric welds, where there are no evidences of any films even at the highest power of the microscope. These ruptures must be at the austenite grain boundaries, because to them the impurities are rejected during the solidification of the metal. In cases of welds where it is possible to distinguish between the gamma and the alpha grain boundaries, as is possible when there is much pearlite, I have never seen a case of rupture at the alpha boundaries. This would seem to be quite natural, because the alpha grains are formed by the recrystallization of the gamma grains, and if there be any impurities at the gamma grain boundaries it is not possible for one grain to grow at the expense of another one past such impurities.

It would hardly be expected that any ordinary heat treatment would alter the character of the ruptures in welds, and if defective welds were heated in an oxidizing atmosphere it might be expected that they would become more brittle. Such tests as I have made indicate that this is true. On the other hand I have found that electric welds which were very brittle as made, were notably improved by heating several hours in a strongly reducing atmosphere at a temperature of about 600 deg. C. This would indicate that the difficulty is one of oxide. The characteristics of welds made by the gas process are their large grain size, their lowness in carbon, manganese and silicon, their maintaining of practically the same amounts of phosphorus and sulphur as in the welding material, and their lack of ductility. It is quite evident that the heat will remove carbon, silicon and manganese, but there seems to be a point in the case of each one of these elments beyond which the reduction does not take place because of the diffusion of them from the base metal into the weld. The same statements are true of electric welds, except that their ductility is less, while their tensile strength is higher when both are made of ordinary material. Welds also offer comparatively slight resistance to alternating stress and shock. Inasmuch as all of these characteristics appear to be due to the presence of oxide, it will be well to consider what means have been taken to prevent oxidation.

Prevention of Oxidation.

Oxidation should evidently be less severe in the case of gas welds than in electric welds. First, because the temperature is not so high, and second, because of the protecting influence of the envelope flame, which is composed of hydrogen and CO burning to water and CO_2. In the electric arc the temperature is very high, and the metal passing over the electrode to the weld is very finely divided, with naturally great oxidation. It will appear clear that if the melted metal could be covered with a protecting slag, oxidation would be much lessened. This has been done for a number of years in electric welding by coating the electrodes with compositions of various kinds which produce slags of various viscosities. If the slag is too viscous it may be entangled in the weld, weakening it, and if too thin it will not protect the metal; but it is a fact that electrodes of this type when properly used give a sounder weld than electrodes made of bare wire. With gas welding no organized attempt has been made to provide such a slag covering. Naturally with the lower temerature a thinner slag will be necessary, but there is also to counteract this the blast from the flame, which has a velocity of about 375 feet per second at the exit from the tip, which tends to blow away the slag and to leave the metal exposed. It is rather curious that nickel steel welding rod seems to provide a very thin slag and produces a weld which is much less oxidized than one made of ordinary low carbon steel. This seems to be due to the formation of nickel oxide. It is noticeable that the scale on a nickel steel weld adheres much more strongly than that on one made of ordinary wire. The microscope shows that this is because of its interlocking with the melted metal. It is entirely probably that before best results will be obtained with gas welding it will be necessary to provide a properly coated welding wire. It might be mentioned incidentally that in the case of non-ferrous metals, such as brass and bronze, much sounder welds are produced when the welding material contains slag forming constituents and when flux is sparingly used, than when other conditions prevail. This would naturally be expected because of the well-known fact that a clean surface of melted metal permits the absorption of gases which are given out during solidification, causing porosity.

While a coated wire doubtless makes a better weld than a bare one, its use is attended by difficulties such as the inclusion of the coating in the weld, and its expense, so that unless the weld must be of superior quality its use is not desirable, and in many cases its use is not necessary either in gas or electric welding. If possible it would be much better to introduce the materials that make the weld clean and sound into the electrode or welding wire, and I think that the ease of doing this is greater with the latter than with the former.

Testing of Welded Pieces.

It has been quite common to make tests of welded pieces usually of comparatively small size in order to determine their strength, but unfortunately in most of these cases the results are either inaccurate, or the conditions under which the work was done have not been given with sufficient completeness to enable comparisons to be made with other tests. Usually nothing is said about the character of the material to be welded, or as it is called, the base metal. It has been stated before that a weld made with a given material cannot have more than a given strength. It is evident that if a weld be made in base metal of 50,000 pounds tensile strength and the weld have a tensile strength of 52,00 pounds that rupture will occur outside of the weld, while if the base metal have a strength of 60,000 pounds, the rupture will occur in the weld. Also, as most of the elongation occurs during the last few thousand pounds in a tensile test, a 52,000 weld in 60,000 base metal will show but little elongation, while with the 50,000 pound base metal the elongation will be that of the base metal itself. Therefore, if the characteristics of the base metal be unknown, no fair conclusions can be drawn from the test. Of course, this is only one factor, and the following information should be given if the results are to be of value:

Chemical analysis of the wire.
Chemical analysis of the base metal.
Tensile strength and other characteristics of the base metal.
Microstructure of the base metal.
Microstructure of the welding wire or electrode.
Tensile characteristics of the welded pieces.
Bending characteristics of the welded pieces, hot and cold.
Size of electrode or welding wire.
Amount of wire used.
Amperes during welding.
Open circuit voltage.
Welding voltage.
Make of torch and size of tip.
Gauze pressure of oxygen and acetylene.

These tests will answer for many purposes, but as welds are more or less brittle and non-resistant to alternating stress, it is almost necessary for complete information to make alternating stress and shock tests. It is not very important as to what machines are used for making these tests so long as the same machines are used where the results have to be compared. It would also be expected that such tests of welds would not be very consistent, and quite a number of tests should be made to obtain a fair average. This is necessary because of the irregular quality of welds even when carefully made. Probably as good a test as any to determine the ability of a welder is the cold bend test.

It is made by making a weld in a piece about 2 in. wide and of a thickness with which the welder usually works. A single "V" should be used and the weld left flush with the base metal. After the piece is cold it should be clamped strongly to the side of the anvil or held in a vise with the bottom of the "V" level with the face of the anvil or the top of the vice jaw. The projecting part can then be struck with a hammer or sledge so as to stretch the top of the weld. The number of blows required and the angle through which the piece bends before breaking or cracking is quite a fair measure of the quality of the weld, but it must be remembered that the character of the base metal again influences the results. Soft ductile material will take much of the bend while hard stiff material will throw the strain more into the weld. Examination of the fracture will show if the fusion has been complete and whether the weld is clean. For a more accurate test the bending can be done in a testing machine by mounting the test piece on supports and forcing a bar of the proper radius against the piece, using the load and the angle to which the piece bends before cracking, as a measurement of the quality.

The hot bend test can be made in the usual way. My experience has been that all ordinary welding materials, both gas and electric, will give in the weld a hot short metal, the hot shortness existing at a bright red heat. I have also found that this red shortness does not occur with some coated wires for electric welding, nor with nickel steel wire in gas welding. This seems to me additional evidence that the brittleness of welds is caused by oxides. It seems evident that a welding material that has no brittle range is quite necessary for use in welding locomotive fire-boxes or similar structures, because where the sheets are overheated, as happens when the water is low, there is much danger of the weld giving way suddenly, and while we all agree that low water should not occur, we also agree that it cannot always be avoided. Therefore, it is wise to use some welding material that will reduce the danger.

In gas welding of cast iron it is permissible to use a tip that is large in proportion to the size of the casting, blocking up the edges to keep the melted metal from running away. But in steel welding by gas, too large a tip will make the metal boil and foam, and is certain to injure the weld. Also in electric welding of steel too heavy a current must not be used. On the other hand too small a tip or current will result in imperfect fusion and a bad weld. This is spoken of because of the tendency in production work to increase the output by forcing the welding, as such a forcing always causes trouble in the quality of the product.

The welder is frequently given all the blame for defective work, and it is true that in many cases he is responsible, but before criticising him too severely, we should consider whether the real responsibility may not lie in other directions. Those in authority should remember that welders as a rule are anxious to do good work. In fact, it is very rare to find any welder who is not eager to learn more about his work, and willing to do anything that will improve it. It is quite common to find crude or defective apparatus in shops that would not think of furnishing apparatus of such a character for other processes, and no mechanic can be expected to do good work without satisfactory tools. Again, those in authority are generally unfamiliar with welding, largely because it is a new process and opportunity has not been afforded them to appreciate the necessity for good apparatus and proper conditions under which to do the work. I believe it is generally true that the management of any shop where welding is used, knows less about it than about any other process they employ. Furthermore, most engineers, not being familiar with the peculiarities of welds, make their designs to suit other forms of construction with which they are acquainted, such as riveting. There are very few welders who have received any real instruction in their work, but have simply picked up what they could. It seems to me evident that the first place this instruction is required is in the management. I do not mean that superintendents or foremen should be expert welders, but they should have a sufficient knowledge of the principles and practices of welding to be able to tell whether the work is being done as it should be done. If they realize their responsibility they will see that proper designs are prepared and the proper apparatus and materials are furnished and used in the proper way.

Another thing that should receive attention is the proper training of operators; and men should be selected with regard to their fitness for the work. Good eyesight is essential and is too often disregarded. The methods of training would differ in different cases, and no more can be said in a general way than that a good foundation should be laid with regard to the fundamentals of handling the equipment. After this is acquired, such training should be carried out as will fit the man for the work he has to do, bearing in mind that routine work requires much less knowledge and experience than is necessary for an all around welder.

Effect of Welding Heat on Base Metal.

All welding operations effect the base metal as does any other method of applying heat, but as the heat is more local, the distance from the weld that is so effected is less than in forge welding. As a consequence the changes in structure may be compressed into a very short space. In any form of welding the heat must be supplied at a greater rate than it is removed from the base metal by radiation and conduction, and in fusion welding it is supplied very rapidly. In the case of electric arc welding of a ¾-in. plate the entire range of change in structure may be found within about 1/16 in. of the line of the V, while in gas welding plates of the same thickness they will occupy about 1½ in. from the line of the V. These changes consist of a coarsening of the grain where the heat is greatest at the line of the V, the coarseness gradually decreasing until a zone is reached where the grain size is the same as that of the original plate. If the plate has been finished at a higher temperature than that due to its upper critical point, beyond this zone there will be a refinement of the grain until the place is reached at which the temperature has been that of the Ac3 critical point, where the grain size will be finer than that of the plate, beyond this again the grain size will increase until it is the same as that of the plate. Beyond the Ac3 line the plate has been subjected only to a drawing heat, which might alter its physical characteristics without changing the grain size. In the electric weld in the ¾-in. plate referred to, which contained between .25 per cent or .30 per cent carbon, there was a marked increase in scleroscope hardness in the zone next the weld, and evidently the greater the carbon the greater would be this increase. In the gas weld referred to, the increase was not nearly so noticeable, being only one or two points, which might be due to other things. The grains next to the weld in the electric weld were sorbitic. Here again is an argument in favor of using low carbon steel for welding, because the effect on it is much less than with higher carbon steels. In fact, in cases of shafts which require metal added to them to take care of wear, it is advisable to preheat them to a black heat to avoid the chilling effect which would otherwise occur. It has been found, for instance, that in adding metal to the crosshead fit of locomotive piston rods, there is danger of the rod cracking at the edge of the weld because of the more brittle structure at that point, unless they are preheated. The coarseness of the grain makes the metal less resistant to shock and decreases its ductility, and though in many cases this is of little importance, it should always be considered.

It would naturally be inquired whether heat treatment would not remove the effects of the heating due to the welding, and it may be said that this is quite possible, but in most cases too costly, because the Ac3 point of the weld is quite different from that of the base metal, both because it contains less carbon and also because it is a casting. This means that for the best results a double heat treatment must be used, the first one at a high temperature, say 1750 deg. F. This, of course, coarsens the grain in the base metal, and it is then necessary to reheat it to about 1450 deg. to refine the grain of the base metal. It seems, therefore, clear that except in unusual circumstances it is not commercially possible to heat treat welded pieces. It should be noted that the annealing to which such parts as shells of tanks are subjected for the purpose of relieving the welding strains, will not alter the structure as a usual thing. Of course, it is theoretically possible to use a welding material that will require in the weld the same refining temperature as that of the base metal, but I doubt if it is a practical solution, because difficulties would arise in its use, if it were plain carbon steel. On the other hand it might be possible to produce an alloy steel that would answer the purpose. Therefore, unless in special instances, the designer of welded parts should not consider the possibilities of heat treatment, but make his designs to suit welds as they are made.

The physical changes in the character of the weld metal have been referred to and it might be well to consider the chemical changes. Any ordinary welding material is low in carbon, that for gas welding having about .06 per cent and that for electric welding about .15 per cent, yet there is always a loss of carbon due to the heat, so that the weld made with such materials does not contain over about .03 per cent or .04 per cent of carbon. Manganese and silicon are also lost, but as would be expected the phosphorus and sulphur do not change. In the case of heavy welding the loss of the above elements is less near the V than in the center of the weld, as there is some interchange of the elements between the weld metal and the base metal, so that in sampling a weld for chemical analysis care should be taken to keep away from the edge of the V, unless proper allowance is made.

While there is a loss of some elements there is a gain in both oxygen and nitrogen. Nitrogen in both gas and electric welding comes from the air, while the oxygen probably also partly comes from the water vapor in the envelope flame in the case of gas welding. It is generally believed that molecular nitrogen has but small affinity for iron at even high temperatures, and this is doubtless true. On the other hand iron ordinarily combines with nitrogen in the nascent condition at 1400 deg. F. as has been proven by numerous tests.

Effect of Nitrogen on the Weld.

There has been much discussion as to the effect of nitrogen on steel, some taking the position that it makes steel brittle and others that it has very little if any effect. The presence of nitrogen as nitride can be quite accurately determined by chemical analysis, but its existence in other forms, such as dissolved gas, cannot be proven in this way. It is usually believed that when it is present in sufficient quantity it combines with the iron, making an iron itride having the formula Fe_2N. In this condition it may be seen as a constituent of the metal in the form of plates lying along the cleavage planes of the grains, and with larger quantities is present as a eutectoid of iron and iron nitride at the grain intersections.

Electric arc welds have the same structure as iron N-ized, except that the structure is much finer because of the rapid cooling. Gas welds may also contain the plates when the metal has been overheated. Similar plates are also visible in samples of Bessemer steel taken just after the blow and before recarburizing. In all three cases the metal has been overheated, and it would seem to be quite possible for nitrogen to combine with iron as iron nitride at these very high temperatures. Of course, there is as yet no mechanical proof that the plates are iron nitride, as they have not been isolated. It is not worth while to discuss the matter here, except as to whether nitrogen is responsible for the brittleness in electric welds made with bare wire.

Direct Process For Steel Manufacture

The Possibility of Using Oil Lignites and Other Fuels—The Blast Furnace and the Direct Process Compared

By A. E. BOURCOUD

PART I

THE subject of this paper "Direct Steel" has formed the basis of speculation and research for the last fifty years with very little to show for it in practical results or constructive theory. This is true notwithstanding the fact that the problem cannot be considered as more difficult of solution than others of a strictly chemical or metallurgical character which have been solved during the same period of time. It may, therefore be considered that investigators have not approached the problem in the right way, or they have failed altogether to take advantage of the data and scientific facts to be deduced from blast furnace practice.

In the following paper the author will endeavor to outline the theoretical requirements of the direct steel process and indicate the possibilities of a successful solution on an industrial scale.

Resumé.

The present paper does not claim scientific nor technical merits of any kind. The author has unpretentiously prepared in a more or less schematic form, some suggestions conducive to the commercial realization of the socalled direct process for steel-making from what appears to be a new point of view.

The conclusions derived from this preliminary survey, give great encouragement and it is believed would justify the semi-industrial scale experiments needed to confirm in a practical way the theories advanced.

The conclusions can be summarized as follows:

(1) That the gasification of atomized oil and powdered coal of any kind presents great possibilities for generating economically, in large industrial units, very powerful reducing gases, emerging from the producer at a sufficiently high temperature for immediate use in reductive operations.

(2) That the economic reduction of iron ore by a current of gases with the employment of working agencies based on the continuous impingement of the gases on the ore, shows great possibilities of large-scale operations, delivering continuously spongy iron, at high temperature, ready to be melted in furnaces of standard types.

(3) That the combined economic efficiency of both operations would make possible the establishment of the iron and steel industry in places where present methods have little chance to work commercially owing to the lack of coking coals, as is the case in California, Texas, Black Sea, and other localities possessing oil; Brazil and Italy, with lignites, and many more with good non-coking coals, like France.

(4) That even in the actual steel districts, the employment of powdered coking coal in the combined suggestion can show favorable economic results competively with our present routine.

Direct Processes in General.

The "Direct Process," used as a term for describing the manufacture of iron by the conversion of iron ore into sponge and then into commercial iron and steel in a single direction, i. e., without passing through any other intermediate commercial product, has been the goal of numerous investigators for many years. The simplicity of the chemical process involved has at all times possessed a strong fascination for inventors and others; and the mere enumeration of the solutions advanced or tests carried out would fill a fair-sized book. Unfortunately, for the advance of the art, none of these experiments were fully successful as regards application of the principle on a commercial scale to compete with the economic results obtained by the present methods.

These investigations lost, in past times, most of their interest and importance after Bessemer's famous invention, which left to the direct process very narrow economical limits within which to develop. In more recent times, from the first serious endeavors of Dr. Gurlt in Bonn, in 1857, up to the most recent attempts, in 1920, all the processes have been complete industrial failures, because although C. W. Siemens, in 1868; Chenot, in 1870; Adams and Blair, in 1885; Stassano, in 1900; and Gröndal, in 1909, succeeded in manufacturing iron, it was by dint of the use of very pure ores and with a prohibitive cost of manufacture, which placed these processes entirely out of the question, irrespective of their relative merits.*

Reviewing past work on this subject, it might at first sight appear strange that taking account of the few factors entering into the direct solution, no perfected process has resulted. The reason for this becomes apparent in comparing previous attempts in direct steel. All experimenters have followed a more or less beaten path, those who came after, arriving ultimately no nearer a solution than those preceding them—in fact, in the most recent trials, the same errors in theory and practice have been duplicated.

Abstract of paper presented before American Iron & Steel Institute, November 18, 1921, New York.

*It will be just to make here one, and a unique, exception, in the continued commercial success of the Sieurin process, worked by the Hoganas-Billesholms A.B.—in Halsinborg (Sweden) with a yearly production of about 8,000 tons of sponge iron of high quality, since 198. However, the special local economical conditions and their derived advantages do not make the process suitable economically for any other locality, as has been demonstrated by the repeated attempts to adopt it in several countries and distinct districts of Sweden. The process works in crucibles and cannot be considered as a solution of the direct process problem, industrially speaking.

A consideration of individual cases indicates that past failures of direct processes are not due to the impracticability of the system, but rather to the misconstruction placed upon laboratory experiments and the application of laboratory conditions in large-scale application. It is doubtful whether the direct process can be built up in this way, depending entirely on theoretical consideration based upon laboratory experiments, as interpreted today.

Blast furnace operation brings to view in one of its steps the possibilities of the direct process solution, although covering by the characteristics of its system an excessive range. In the opinion of the writer it has many possibilities to be solved by entirely different means, with the additional advantage of suppressing the intermediate and contaminative zone which forms the link between the reduction of the iron oxide and the melting of the reduced iron, the two real achievements of the blast furnace.

The Direct Process Problem.

Direct process investigations and propositions are generally received by a large majority of iron masters and industrial iron metallurgists with marked indifference and suspicion, considering the issue as being a futile and pedantic attempt to replace and outshine our modern blast furnace—the base of our steel industry—with all its accumulated improvements, large tonnage production, long practice and established traditions. This assertion has to be modified for lack of proper foundation, as it does not represent the real situation in either its true industrial form or its purely scientific aspect.

Cast iron is the principal commercial product of the blast furnace. Taken alone as a process for the direct manufacture of cast iron, it is universally recognized as one of the most perfect metallurgical working agencies in existence. Its present state of development has practically reached its final stage, leaving very little opportunity for further improvement. This is the aspect of the critic of the direct process but it is not the issue.

The greater and by far the most important industrial use of cast iron is to serve as raw material for conversion into steel, either by the Bessemer, the Open Hearth, or by any other process. With this application, the blast furnace, broadly speaking, becomes in its greater field of action, an adjunct to the steel plant, losing all its individual economical characteristics, becoming a part of a more complex system of manufacture, whose merit has to be judged by the collective work accomplished by the whole group as a single unit, and not by any particular one of its components. This is the true aspect of the question and the real issue.

Marion Howe has said that cast iron is a grade of steel. The trouble is that the blast furnace goes further than necessary, passing during the course of its work through the steel grade of steel without any stop, to arrive finally at the cast iron grade of steel, and the product has to be brought back, with extra fuel, labor, capital investment and the inevitable loss of metal.

To appreciate at first sight to what extent these drawbacks are influential in the industrial results, nothing is better than to suppose, for the moment, that the blast furnace, with the same amount and kind of fuel, labor, material and expenses, were able to produce directly, the steel grade of steel instead of the cast iron grade of steel which it usually produces — the former being a product necessitating, notwithstanding, less reductive work and the same general conditions.

Comparing this direct steel blast furnace with the combination of the cast iron blast furnace and the open hearth, or even the converter, it would be found under ordinary conditions, that per ton of melted final product, the ratio of fuel consumption would be as 100 to 125; the total capital investment as 100 to 175; the cost per ton without profit, but with the usual fixed charges, as 100 to 135; and finally, taking the minimum market value at which the product manufactured by the combination can be sold, the return on the total capital investment would be 42 per cent and 6 per cent per year respectively. It is these comparative industrial aspects that furnish the reasons for the exiting incentive for possible improvement.

In comparatively recent years interest in the research on direct production of steel in accordance with modern lines has been revived, and a few eminent metallurgical authorities like the late Prof. Wedding, of Berlin; J. O. Arnold, of Sheffield; A. Standfield, of Montreal; and J. W. Richards (recently deceased), of Lehigh, Pa., have had the courage of their convictions in maintaining an independent attitude notwithstanding the general indifference, especially of those who should ultimately be the ones directly and materially benefited by any valuable contribution.

The Blast Furnace and Direct Processes.

To start with, and to be quite fair, it should be mentioned that the blast furnace—of which we are so justly proud—was not invented with the intent of producing cast iron, but rather it is the natural evolution of the old Osmund and Stuckofen types of furnaces, which were nothing more than the results of vain attempts during the thirteenth century to industrialize the Catalan Forge, with the main object of producing sponge iron in large quantities, but finding, instead, a new and unexpected form of final product.

When cast iron appeared in the fourteenth century, it was the most undesirable and unwelcome product to the iron makers of the day, as they did not know what to do with the new metal and how to handle it. The changed method was accepted, however—even though it was not all that was desired—as being a more economical solution and providing larger reducing units for treating iron oxides. It, however, created new and important problems to be solved, at the same time giving birth to the real metallurgical inventions which were found necessary to convert the cast iron back to soft iron again, the soft iron being the final product sought.

The finery, the puddling, the converter, the open hearth and all its modifications have followed, meanwhile the blast furnace firmly established as their raw material purveyor, improved rapidly up to its present state, keeping always within the original and fundamental lines. It is today the solid base of our huge steel manufacture, together with the Bessemer converter and the Siemens-Martin furnace variations.

Reviewing in general the action on the charge through the different working zones of the blast furnace, it can be divided into three main stages (1) preheating, preparatory to reducing; (2) reduction by gases, practically completed; (3) prepartory overheating, completion of reduction, and melting, through a very strong reductive fusion. The work is continuous, the stages overlapping each other, with the appearance of a flexible arrangement, but forming in reality a rigid system without elasticity or independence.

Considered from a chemical engineering point of view, the most important and complete of the different stages, is the reduction of the iron oxides by the ascending current of gases; it is perfect in action, constant and reliable; its practical results have never been duplicated in any of the numerous attempts made in the direct methods. It is the fundamental operation of the blast furnace, and its highly efficient work has made good and acceptable the other inconveniences typical of the system.

Of the remaining two stages, the first or pre-heating, is not only incomplete, but harmful to certain elements due to its overlapping and reducing influence; the third, or overheating and melting operation as it is carried out, is the main cause of the extreme difference between the two products—cast iron and steel—due to the reduction of undesirable elements by the unavoidable presence and contact of large masses of solid carbon at the critical moment where it is less desired.

We may conclude from this preliminary survey that in order that a direct process may take due advantage of the blast furnace experimental data, all the above mentioned working stages must be planned as independent operations and independently regulated so as to establish a flexible system which will at the same time be more adaptable to varying conditions. The first stage or preparatory heating has to be improved; the second or reduction has to be duplicated, if possible; and the third or melting, radically changed.

Such an arrangement means a complete departure from blast furnace lines, inasmuch as the two final products demanded are so fundamentally different, although so near in their generic form. This necessity has been recorded by the majority of experimenters.

By adopting a proper pre-heating operation under decided oxidizing influence, we have the necessary improvement of the first stage, and by melting with modern agencies under special atmosphere and out of contact with any fuel, we can change radically the third. Then the stages first and third can be satisfactorily arranged in the right direction with only our present knowledge, experience and approved working agencies.

With reference now to the second stage, how and with what means it should be possible to effect, under the new conditions, a positive duplication of the practical results of the reduction carried out in the blast furnace, is what in reality constitutes the backbone of any direct steel proposition, as has been recognized by all previous investigators.

It is within this scope that the problem is considered here in this unpretentious essay, and a possible solution suggested with all the appearances of a practical realization, under the economic conditions required to place the process on a favorable competitive basis with our present methods of manufacture.

Both methods of carrying out the reduction have their respective partisans, and have been the subject of many controversies in the numerous trials and experiments since the first attempts made in the direct proposition.

Without discussing and questioning here whatever might be the merits and advantages of the employment of solid carbon intimately mixed with the iron ores, it is a recognized fact that the complete reduction of the ore in the solid state with only the agency of solid carbon in order to obtain a solid deoxidized product, is physically impossible owing to the lack of adequate cantact of the reducing agent with the inner part of the grains of ore, no matter what is the degree of fineness of the grinding and the homogeneity of the mixture. The practical results obtained with this method of procedure are, however, due to the beneficial influence or action of the gases evolved in the operation. Were it not for that help, the reduction would be faulty and incomplete. If the gaseous phase takes such an important part in the most critical period of the penetration and completion of the reaction, there is no doubt that the whole operation can be carried out also with gases alone, provided these gaseous reducers are placed in the right and necessary conditions to do thorough work as is the case of the blast furnace.

The present investigation belongs to the class of processes based on the employment of gaseous reducing agents alone, without contact of any kind between solid fuel and the ore charge, either in the reduction or the melting operations.

AWARD SAFETY DIPLOMAS TO FOREMEN.

Graduation exercises in McCreery's Restaurant, Pittsburgh, Thursday evening, November 17, marked the conclusion of the largest and most successful Foremen's Safety School ever conducted by industrial plants in the United States. The graduating class numbered approximately 750 and each graduate received a diploma from the National Safety Council.

This safety school, for foremen of industrial plants in the Braddock District, was inaugurated by the General Superintendent of the Edgar Thomson Steel Works, O. J. H. Hartsuff, and was originally intended for the instruction of his own foremen in safety matters. Later, however, Mr. Hartsuff widened the scope of the course to include foremen from all the industries of the district, and the various plants of the district were represented on the committee which had charge of arrangements: John B. Trusel (Edgar Thomson Works), Chairman; J. A. Oartel (Carnegie Steel Co.), J. E. Lose (Carrie Furnaces), Thos. Crombie (McClintic-Marshall Co.), S. Baum (Columbia Steel Shafting Co.), John D. Price (Wilson-Snyder Pump Co.), Peter Toner (American Chain Co.), A. R. Blainer (Consolidated Expanded Metal Co.), A. M. Kremkau (Copper Clad Steel Co.), John Hockenberger (Benner Tool Co.), E. M. Paterson (Duquesne Light Co.), L. H. Lesimore (Nicholson Chain Co.), Jas. Weeks (Pittsburgh Machine Tool Co.), Jos. Tronsberg, Jr. (Acheson Mfg. Co.), B. D. Peters (Rankin Works, American S. & W. Co.), George Garver (Braddock Works, American S. & W. Co.), Jos. Connor (Sterling Steel Foundry), D. R. Ferguson, J. A. Morgan, David Scott, F. A. Power, F. H. N. Gerwig, Jos. A. Lawler, John Lloyd and F. F. Slick, all of Edgar Thomson Works, W. Milroy (Union Railroad), and F. R. Wilhelm (Pittsburgh Railways). All meetings were conducted by E. S. Willis of Wilkinsburg, Pa.

The auditorium of the Braddock Carnegie Library was packed to capacity for each session of the course, which consisted of addresses on safety subjects by Dr. R. M. Little (N. Y. Industrial Commission), J. A. Oartel (Carnegie Steel Co.), John Martin (Ohio Works, Carnegie Steel Co.), F. H. Trego (Pittsburgh), E. Friedlaender (Edgar Thomson Works) and Dr. Wm. T. Dorward (Milwaukee).

Relation of the Iron and Steel Industries to the Chemical Industries

Review of the Chemical Products Consumed by the Steel Industry. —Steel and Chemical Industries Are Closely Allied

By JAMES M. CAMP
Director, Bureau of Technical Instruction
Carnegie Steel Company, Pittsburgh, Pa.

CLASSIFIED according to their direct relations to our natural resources and with respect to their dependence for raw materials, our industries are basic or subsidiary, according to the way they are grouped, and dependent. The basic industries are those engaged in the production, or creation, of raw materials by life processes, such as farming; or in the extraction of raw materials from the earth, such as mining or oil and gas-well drilling; or in the conversion of natural potential energy into useful forms, such as our hydroelectric plants. But these industries must be supplemented by a number of others, which, although they are directly dependent upon these basic industries for raw materials and mechanical power, are so intimately related to the former by reason of their being engaged in converting and adapting certain raw materials for use that they must be accepted as coordinate to these basic industries and also coordinate to each other. Hence, all these closely related industries are to be looked upon as being subsidiaries to our industrial life as a whole.

To explain more fully what we mean to imply by this use of the term "subsidiary" it is necessary to point out that we apply this designation to groups of closely related industries rather than to any specific activity. Thus farming, for example, is really a class term, for under it are included such occupations as gardening, cattle raising, fruit growing, and the growing of grain, also the sciences that relate to these arts. From this standpoint we are able to separate our industrial life into a number of divisions, which we shall term the subsidiary divisions of industry. For want of better names, we designate the basic subsidiary division devoted to the production of raw materials by life processes as the agricultural division; that devoted to the extracting of raw materials from the earth as the mining and well-drilling division; and that devoted to the transforming of natural energy as the hydroelectric division. As to the dependent subsidiaries, we call that one devoted to the separation and refining of the metals the metallurgical division; the one devoted to the preparation of refractories, bricks, all clay products, as well as glassware, etc., the earth-products division; and that devoted to the production of chemical compounds, the non-metalic elements, and certain of the rare metals, the chemical division. Some of you may think of other industries that should possibly be included as another division, but we believe that any of our industries can be placed under one or another of these divisions.

One of the things we wish to emphasize now is the close relation and interdependence of all these grand divisions of industry. So we would call your attention to the accompanying diagram, which will both demonstrate and vividly illustrate the point we wish to make. This diagram shows that these subsidiary divisions of industry are closely connected and related to each other because they are dependent upon each other for necessary raw materials and supplies, and are each made up of a number of related industries so important that they are usually spoken of as being, themselves, the basic industries. Each of these industries is accompanied by a list of dependent industries so long that it was found impracticable to show them on this diagram. It is such a subsidiary division of industry, not a small branch of industry nor yet one of the dependent industries, that we have in mind when we refer to our chemical industry. It consists of the chemical industry proper and a great number of dependent industries, which, though they are not engaged primarily in the production of chemicals as such, produce articles of a chemical nature, or by chemical processes, or articles that depend mainly upon chemicals. The chemical industry proper has, itself, three branches, which are known as the chemical section, the acid section, and the coal-tar section.

Referring to the other part of our theme, we see in our country today a single branch of the subsidiary metallurgical division developed to such a high state of efficiency, and on that account occupying such a high position commercially that it casts a shadow over the importance of even the subsidiary divisions. Such an industry is the steel industry. And here lies great danger for us, in that we may be led to attach too much importance to one industry or one division of industry and not enough to the others. Trying to decide which of these grand divisions of industry is the more important is like trying to decide which wheel of an automobile is most important, for they form the vehicle upon which our civilization is riding towards that goal set up for it from the beginning, when man was commissioned to replenish the earth and subdue it.

As we consider these relations, we feel like an artist must feel when he gazes upon the beautiful sunset, the raging storm, the mighty ocean, or the clear blue sky, and realizes that here is a changing beauty, here a host of forces, here a vast expanse and depth, and here an endless space that he can never paint. For

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Paper read before the fall meeting of the American Iron & Steel Institute, November 18, 1921, New York City.

if our industries are as interdependent as we have shown them to be and if the relations of our industries to the future peace and progress of this nation and to the health, comfort, prosperity and happiness of its people are what they seem to be, then, indeed, we do have to deal with very important matters in the direction indicated by our subject. All our material progress is largely a matter of progress in our industries. And whatever disturbs one division of our industries disturbs all our industries. In short, our industrial prosperity depends upon the maintenance of a certain balance among all divisions of industry; and with abnormal conditions in one we cannot have normal conditions in any. The limits of time, of our capacity, and of your patience will not permit us to set forth these themes in their entirety, but like the artist who is glad to select a few colors from the sunset, a rolling cloud from the storm, a little section of the ocean surface, or a little speck of space from the sky to indicate what he hopes that those who view his pictures can supply from their own knowledge and imaginations, so are we glad to be able to present to you a picture of the relations between only a few spokes in two of our industries, which hitherto have represented the front wheels of progress.

As the most important branch of the metallurgical division of industry, the steel industry cannot escape certain relations with the chemical industry, and it is interesting to note that these relations, both direct and indirect, are to an unusual extent interdependent. This interdependence is most vividly set forth when we consider these two industries from the standpoint of being consumers of each other's products.

In reviewing the chemical products consumed by the steel industry, we find that sulphuric acid heads the list both as to quantity and importance. Statistics showing the quantity of this acid consumed by the whole steel industry of this country have never been compiled. We do know, however, that during the year 1920 the United States Steel Corporation used approximately 280,400 net tons, all of which was concentrated to give, on an average, a gravity test of 60 deg. Baumé. This fact leads us to the confident belief that our steel industries as a whole must have consumed last year at least 600,000 net tons of this acid, expressed on the standard gravity basis of 50 deg. Baumé. To make a striking comparison, the acid consumed during the year 1919 by the Steel Corporation alone amounted to almost 10 per cent of the total quantity of this acid reported by the Census Bureau as having been made in this country that year. Of this acid used by us, nearly one-half finally went into the manufacture of ammonium and iron sulphates and thus represented a recoverable outlay, but the remainder represented an actual consumption, from which there was no such recovery of acid or any other direct tangible return for the outlay. As to the direct purposes to which we put the acid, not used in the manufacture of ammonium sulphate, a small portion was used in washing benzol and other homologous compounds produced by by-product coke plants, a smaller portion was consumed in making chemical analyses, and the remainder was employed for pickling. The pickling process consists in immersing the steel in a warm dilute solution of the acid, and has for its purpose the removal of scale from the surface preparatory to tinning, galvanizing, cold rolling, cold drawing or chipping.

Concerning the necessity for pickling, this operation, as all of you know, is absolutely essential in the manufacture of steel wire, of tin and terne plate, of galvanized sheets and tubes, of cold drawn seamless tubing, and of all sheets requiring a highly finished and polished surface; and, as a means of revealing surface defects in billets and blooms, it is a great aid in the manufacture of high grade steel, such as that required for forged and heat treated articles. Other agents could be used for some of these cases, but the cheapness, chemical activity and high volatilization temperature of sulphuric acid make it the most satisfactory reagent that can be employed for this purpose.

The next items in point of quantity consumed by our corporation during the year 1920 were muriatic, or hydrochloric, acid and sulphur itself. Of the 10,200 net tons of the former consumed, some was used for pickling in processes where sulphuric acid is not suited to the conditions, such as the final pickling in galvanizing; some was consumed in our chemical laboratories, where it is used in practically every analysis made; some was neutralized with zinc to form part of the flux used in the manufacture of tin and terne plate; and a small portion was applied to various other purposes too numerous to mention here. The greater portion of the 22,000 net tons of sulphur used by us was consumed in the manufacture of sulphuric acid, which we also make as a by-product in zinc smelting, but a considerable portion was employed in the manufacture of certain grades of steel, in the galvanizing of sheets, and in the erection of acid-proof water-tight brick tanks.

The fourth and fifth items next in importance are salammoniac, or ammonium chloride, and soda. During the year 1920 our corporation required almost 7,500,000 pounds of salammoniac and a little more than 1,120,000 pounds of soda, most of which was in the form of the hydroxide, commenly known as caustic soda, and the remainder in the form of the carbonate, or soda ash. The salammoniac was used chiefly as a flux in the application of tin, terne and zinc coatings, but a small quantity was consumed in the laboratories and shops, where it is indispensable in some work. With the exception of small amounts used in our laboratories and for cleaning purposes, the soda was employed in our plans for the neutralization of acids and corroding compounds, such as in the washing of benzol products and the softening of water for boiler use. Its effectiveness and the importance of its use for these purposes are matters that need not be elaborated upon nor emphasized here.

Other items that may be of interest to certain organic chemists are the 6,000,000 pounds of palm oil used in the tin plate plants of the corporation during 1920, the 63,477,000 gallons of fuel oil consumed, and the 3,264,000 gallons of straw oil required for the absorption of benzine and its homologues from our coke oven gas. Tar oils may be substituted for the straw oil, but no satisfactory substitute for the palm oil has yet been found, though such a substitute has been diligently sought.

A small item is nitric acid, of which we consumed nearly 6,000 pounds in 1920. The use of this acid is restricted to laboratory purposes almost exclusively. During the same year, our requirements for the nitrate of soda called for more than 3,500,000 pounds of this salt, most of which was employed in the manufacture of sulphuric acid.

Next comes a long list of chemical articles for which we have no data whatever as to the quantities consumed by the steel industry. Their importance, however, is apparent as soon as they are named or the uses to which they are applied are indicated. This list includes the various chemicals used in our laboratories for analytical purposes, and such substances as lubricants, soaps, salt, carborundum and compressed oxygen. From a thousand to twelve hundred pounds of elementary phosphorus is also consumed in the preparation of phosphor bronzes for use by the steel manufacturers.

Not only are the iron and steel industries large consumers of chemicals, hence good customers of the chemists, but the chemical industries are likewise large consumers of iron and steel. We have been unable to secure statistics as to the tonnage of iron and steel used by our chemists, but, judging from our knowledge of these industries, we know it must be large. The chemists deal largely with matter in the liquid and gaseous states, hence their apparatus consists of such vessels as stills, retorts, vacuum driers, pipes, tanks and various other containers, many of which are made of iron or steel entirely, while the remainder require these materials in their construction. They have need of much steel in the form of plates and sheets for vessels, ranging from tin cans to tank cars, in which to transport and market their materials. They employ much machinery, such as fans, rolls, pumps, presses, crushers, disintegrators and centrifugal machines, and, of course, require engines and motors to operate these machines. They require steel for their buildings, which usually must be fireproof; in 1919 there were more than 1,300 establishments producing chemicals, 811 of which were devoted exclusively to the chemical industry proper.

But it is in the sense of a prospective customer that the steel industry should show the keenest interest in the chemical industry, for the former has, to a considerable extent, gradually worked itself into the position of a producer of certain chemicals and raw materials for the latter industries. Thus, during the war the scarcity and consequent high price of potash brought about the installation of apparatus for the recovery of this product from the dust in blast-furnace flue gases wherever the amount of potash driven over with these gases would justify the expense. Similarly, a desire to eliminate waste led the steel industry several years ago to begin the manufacture, from spent sulphuric acid, of ferrous sulphate, commonly known as copperas or green vitriol. The production of this salt for the year 1919 amounted to almost 60,000 net tons, practically all of which we can be reasonably sure was produced by the steel industry.

This salt is used in paper making; in the tanning of some leathers; in water and sewage purification; in the manufacture of fertilizer from packing-house waste; on the farm as a spray and disinfectant for the eradication of weeds and the prevention of certain diseases among plants and animals; and in the preparation of inks, certain pigments, shoe blacking, ferric sulphate, stock foods, and a few drugs and medicines. A new use for this salt has been found in the briquetting of blast-furnace flue dust, in which process it acts as a cement, making the briquets produced by pressing hard and strong. It is also used in the purification of artificial gas from hydrogen sulphide and hydrocyanic acid gases, for which purpose there are two general methods, known as the dry and the wet methods. In the dry processes the sulphate is mixed with equal volumes of lime and moist sawdust, which are then pressed into a cake and roasted. The roasting burns out the sawdust and leaves a porous mass composed of iron sesquioxide and lime intimately mixed and ready to be charged into the gas scrubber. In the wet processes, which are more efficient in the removal of hydrocyanic acid, the gas is scrubbed with a concentrated solution of the sulphate, and ferrocyanides are obtained as by-products. A lime and iron oxide mixture similar to that just described for the dry process is now obtained by one of our companies in the purification of mine waters. As this mixture does not require roasting, it is easier to prepare than the sulphate mixture and is very effective and economical as an agent for removing sulphur in coke-oven and other retort gases made from coal.

It should be noted in passing that a similar desire to utilize what would otherwise remain waste products urged us many years ago into the manufacture of cement from blast-furnace slag, of phosphate fertilizer from basic slag, and of paints containing zinc oxide and white lead or iron sesquioxide as base pigments. Although viewed with much prejudice and suspicion in the beginning, the high quality and economic importance of these by-products of the steel industry are now generally recognized.

Again, the change from the beehive to the by-product method of coking coal has brought the steel industry into the most intimate relationship with the chemical industries, particularly the coal-tar branch. This change has created an almost unlimited supply of ammonia and the chief raw materials used by the coal-tar chemists. Ammonia can now be produced at the by-product plant in three forms, namely, as ammonium sulphate, as concentrated ammonia liquor, and as ammonium chloride. The chief outlet for this ammonia lies in the direction of the fertilizer industry, for which purpose the sulphate is employed. The salt is seldom applied alone to the soil, but is used in the various fertilizer mixtures, for which purpose it is well adapted because it will neither revert the acid calcium phosphate nor react with the other fertilizer ingredients to render unavailable any part of its own nitrogen content. It is especially beneficial to some of our soils which contain an excess of the alkalies and to others that lack sulphur. In the latter it fulfills the double purpose of supplying both nitrogen and sulphur, two elements essential to plant growth. A process for recovering ammonia in the form of the chloride, which happens to be the form in which about 90 per cent of the fixed ammonia is given off by the coal, has been recently developed so as to be applied on a large scale. The perfecting of this process will make it possible to produce this salt in large quantities and possibly in a highly refined state. Thus, another element has been added to the list of coke by-products, and the field for the disposal of by-product ammonia has been widened.

Omitting alcohol and the compounds of sulphur and hydrocyanic acid that can be made or recovered from coal gas, the other products of the by-product plant are the chemical compounds zenzene, toluene, xylene and naphthalene, and the mixtures known as light-runnings, wax, resin and tar. Commercially, the first three compounds, as well as mixtures of these substances, are known as benzol, toluol and light and heavy paththa. These compounds, together with tar, form the raw materials for the coal-tar branch of our chemical industries. The finished products that can be made from these raw materials are numbered by hundreds, but, classified, the finished coal-tar products consist of dyes, color lakes, explosives, disinfectants, medicines, phenolic resins, flavors, photographic chemicals, and perfumes, in about the order of their total money values per annum. According to the statistics compiled by the Census Bureau, the weight of these products for 1919, excluding disinfectants and explosives, amounted to 82,532,400 pounds, and were valued at $84,515,500, or an average price per pound for all finished products of about $1.05. A comparison of this average price with the 1919 prices obtained for the crude products at the coke works, which ranged from three-fourth cents per pound for tar to ten cents for the purest paththalene, shows how the values grow in passing through the hands of a chemist. In addition to these finished coal-tar products, there were produced in unknown quantities several crude and intermediate products, the total value of which is stated to be approximately $49,000,000.

At this point it may be of interest to note the rapid growth of this branch of our chemical industries. In 1914 the total value of all the coal-tar chemical products produced in this country was approximately $9,000,000, and with the exception of tar refiners and about seven small plants engaged in assembling imported intermediates into dyes, there were no establishments devoted solely to the manufacture of finished coal-tar products of any kind. Now, according to the recent census taken by the United States Tariff Commission, the total number of firms engaged in the manufacture of coal-tar products in 1920 was 213, of which 82 were engaged in the manufacture of dyes alone. These firms produced more than 206,000,000 pounds of the semi-finished products known as intermediates and more than 67,000,000 pounds of finished dye stuffs. The discrepancy between the tonnage of intermediates and finished dyes is brought about in two ways, namly, some of the intermediates are produced from other intermediates, hence may appear twice in our total, while others may be used for the manufacture of other substances than dyes. All of these intermediates can be made from benzene, toluene, xylene and naphthalene, and are very numerous, as many as 46 being derived from naphthalene alone. Concerning the number of dyes, our chemists made 360 separate dyes in 1920, some of which were never made before. We hesitate to give any figure as representative of the number of other coal-tar chemicals, for new ones are being discovered with bewildering frequency. If we can do so without appearing unduly boastful, we would like to declare in this connection that American chemists during the past five years have led the world in the discovery of new coal-tar chemicals.

Another comparison of perhaps greater interest to us in this: The 82,500,000 pounds of finished coal-tar chemical products produced in this country during the year 1919 is equal to only a little more than one-third of the total weight of the benzol products and less than one-tenth of the tar produced by the Steel Corporation alone during the same period. Now, the processes of the coal-tar chemist are all synthetic, so that his finished products generally show a gain in weight over the basic raw materials, except in the case of tar, of which only about 15 per cent is available for synthetic purposes. So, keeping in mind that the Steel Corporation probably made considerably less than half of all the tar and primary benzol products produced in this country, we have evidence enough that the production of coal-tar chemicals was not limited by a scarcity of raw materials. Yet, for this reason or that, we have found the coal-tar chemists importing some of these same raw products. Let us cite one case to illustrate a point we wish to make. A certain by-product coke plant operator, under the impression, which he had gained in dealing with the coal-tar chemists themselves, that for the manufacture of certain naphthalene dye intermediates the purest naphthalene obtainable was required, proceeded to install at great expense apparatus wherewith he would produce practically c. p. naphthalene, or at least naphthalene with a melting and a boiling point range of one degree. This gentleman then felt reasonably sure of getting a good portion of the business in high grade naphthalene, but less than two months after completing his fine new plant he found his best customer importing naphthalene at three cents less per pound than he was asking—yes, but of inferior grade and with a boiling point range five times as great. Now, either this dye maker had intentionally misrepresented his requirements with the idea of getting something for nothing, if he could, or he suddenly discovered he did not need as good a grade of naphthalene as he thought. This incident illustrates a lack of sympathy and co-operation between these two industries that we hope is, or will soon become, very rare.

Fortunately, and also unfortunately, the steel industry does not rely upon the coal-tar chemical industry in disposing of these coke by-products and neither does the coal-tar chemical industry rely upon us for its supply of raw materials entirely. The steel industry finds a ready sale for all its benzol and toluol and a part of the naphtha as motor fuel, while the remainder of the naphtha and all of the naphthalene and tar can profitably be used as fuel in the steel mills. On the other hand, the coal-tar chemists can look to the gas manufacturers for many of their basic raw materials, and, indeed, so far as the refining of tar is concerned, they rather prefer certain gas tars to coke-oven tar, as the former usually contains a higher percentage of the more desirable light and middle oils. This is the unfortunate side of this condition, that it does not promote the spirit of sympathy and helpfulness that goes with a mutual dependence. All tar, however, contains a high proportion of pitch, for all of which it is difficult to find a ready market. But the coal-tar refiner would be relieved of his "burden of pitch" and the by-product coke operator would receive more money for his tar, if some plan were evolved wherein the tar could be roughly fractionated at the coke plant, where the pitch could be mixed with raw tar and used as fuel or charged into ovens and converted into coke.

Leaving for a time the points of direct contact between these two industries, let us examine briefly their indirect relationships. For, whether the matters just discussed are viewed with concern, as being of importance, or with indifference, as becomes trifles of little consequence, the steel and chemical industries are indirectly connected in ways that are vital to the welfare of both. To prove this statement the mere mentioning of a few of these indirect relationships is all that is needed.

One of these indirect relationships has to do with the fact that certain products of these two industries are absolutely interdependent for their effectiveness. We consider, for example, the dependence of liquified and compressed gases upon the high tension seamless steel tank, and then reflect that without the development of and the demand for such gases there would be no demand for the tanks. In the latter case the steel industry would have missed a good business, for taking the case of compressed oxygen alone, the 1,200,000,000 cubic feet or more of this gas compressed yearly requires the constant use of about 2,000,000 tanks to contain and market it. Similarly, we find steel tubing and ammonia working together in our ice plants, drills and powder in our mines, firearms and explosives on our battle fields and on our hunting grounds, and automobiles and gasoline or benzol everywhere.

Again, we find that the steel and chemical industries are connected in a similar indirect but vital manner through their more direct relations to certain other industries. In a word, both steel and chemicals are first essentials to many industries. We have already pointed out the interdependence of our basic subsidiary industries, upon which all our other industries depend, and now we wish to call your attention to the fact that some of our most important special industries are so completely dependent upon steel and chemicals, that if they were denied either of these two classes of materials, these industries would be totally ruined. A notable example is supplied by the electrical industries. Without chemicals for batteries and insulating materials, or without steel for magnets, armature cores, transformer cores and other vital parts of electrical machinery, the whole industry would be handicapped and certain branches would be impossible. Similar conditions with respect to steel and chemicals prevail in the telephone and telegraph industries, the textile industries, the rubber tire industry, and many others of more or less importance.

As a third important way in which the steel and chemical industries are indirectly connected, we would point out the fact that progress in one industry promotes progress in the other. This fact has been impressed upon our minds time and again in our laboratory experience. The history of our steel laboratories reveals a perfect synchronization of progress in these two industries. The efforts of our steel chemists to improve their methods of analyses have been accompanied by efforts on the part of chemical manufacturers to improve their products and discover new reagents; needless to say, the success of the former has stimulated the latter and the successes of the latter have frequently made possible the success of the former. For example, the development of compressed oxygen made possible the determination of carbon in iron and steel by the direct combustion method, and this method was in use less than two years before new and more efficient substances for absorbing carbon dioxide were brought forth by the chemical manufacturers. The result of this combination of effort has been to reduce the time of a carbon determination from one hour to less than ten minutes and the chances of error in the proportion of about five to one. Likewise, the development of ammonium persulphate several years ago made possible new methods for the determination of manganese, whereby the time consumed in the analysis of steel for this element has been shortened from thirty or forty minutes to about five, with the added advantage that the results are more dependable. We could cite many other cases of a similar character, but will pass over these to mention the latest example of this kind, perchloric acid, which is a reagent of marked chemical activity that has but recently been put on the market. Experiments conducted within the last year in some of our laboratories have indicated that this acid may be used to great advantage in getting into direct solution for analysis certain cinder and ores, which heretofore have been dissolved with great difficulty. All progress of this kind tends to give us better control of the various metallurgical operations and results in a corresponding improvement in the uniformity and quality of our products.

Other examples illustrating this point and appealing especially to the plant operator may be cited. Thus, every mill worker knows what a boon compressed oxygen as a cutting agent has been to the steel plants and structural steel workers in general, making easy tasks that once involved much time and labor and often the safety of the workmen as well. Similar statements can be made of carborundum, acetylene gas, thermit mixtures, and many other substances developed and brought forth by the chemical industries. We remember reading some thirty years ago an article on the importance of weathering and aging steel for forging. It appears that it was then the practice with certain forge shops to keep their billets lying out in the weather for three or four years before working them up. The rusting of the steel either eliminated the surface defects so injurious in small forgings or uncovered them so that they could easily be detected, thus permitting a better selection of steel for different purposes. Improvements in the processes of manufacturing sulphuric acid resulted in so cheapening it that it was available for the pickling of blooms and billets; and the removal of the scale and exposure of the surface defects in steel is now accomplished in an hour and a half.

Before leaving our subject we would speak of one other phase of the indirect relations between these two industries. This matter, while it is less tangible than those things we have just been discussing, is nevertheless, of vital importance. We refer to the common relation of the steel and chemical industries to the welfare and safety of our country. It is self evident that the strongest nation is the independent nation, that is, the nation that does not have to rely upon its neighbors for any of the basic or critical supplies. Such an independence is based upon two commodity factors, namely, natural resources and the industries to develop them. As to the natural resources, this country has been blessed with a full line, with the exception of combined nitrogen, which deficiency, fortunately, can now be supplied by our by-product coke ovens and our prospective nitrogen fixation plants. Fortunate for us, also, we can now say, although not with pride, since we were forced to it, that the last link in the chain of our industrial independence has been forged. This link is about to be subjected to the severest commercial tests, and whether or not it can withstand the tension of selfishness, prejudice, and ignorance at home and the strain of competition from abroad, depends upon how big a load we permit these things to become.

This new link in our industrial chain you will recognize as the coal-tar branch of our chemical industries.

Its present importance to us in peace times is indicated by the value of its products for 1919, which we have just stated. Its future importance we can only imagine, for it is still in the rough, and capable of much further development. Indeed, none of our other industries present such a field of unexplored potentialities. For its importance in war times, we need only to refer to its position in the late world war. If Germany ever again is the maker of our dyes, German poison gas will again suffocate our soldiers. To overcome prejudice and misrepresentation at home, let all our people know we can and do make as good dyes as were ever made prior to the war. Dyes, like the different varieties of steel, can be misused and also injured by the way in which they are applied. The excuse we so often hear that our colored textiles fade because they are dyed with American dyes is a fallacy that may cover either cupidity or ignorance in the proper use and application of our dyes. To overcome the mistakes of ignorance, which, by the way, are mainly of a commercial nature and not of the technology of coal-tar chemistry, requires time, experience, and the closest co-operation of all those concerned. Since they compose the two groups that would be most seriously affected by the destruction of this industry, the last part of this statement should be especially emphasized among both the makers and the coal-tar chemists, who, we fear, are not always so frank and business-like in their dealings with us or with the public as they should be, for their own good.

While we maintain that all our industries are equally important to the physical comfort and general welfare of our people, we can also say that no others have contributed so much to our safety and progress as the steel and chemical industries. In times of war they have supplied our chief means of defense and in times of peace they have furnished us with tools wherewith we have hewn our way to material successes. And now we plead for more sympathy and co-operation in these industries to the end that they each may continue to contribute more and more to the security and prosperity of our own nation and to the advancement of all mankind.

Heat Treating of Tool Steels

The Effect of Rates of Heating, Temperatures and Quenching Medium Upon the Dimensions of Cylindrical Pieces of Tool Steels.

By L. A. LANNING*

THE samples used for the test were cylinders three inches in length and five-eighths of an inch in diameter. They were cut from a single bar of tool steel which had been annealed at the steel mill.

The analysis of the steel used was as follows:

Carbon	1.10	Phosphorus	.020
Manganese	.30	Sulphur	.020

All measurements were made with a Pratt & Whitney measuring machine reading directly to a ten-thousandth of an inch.

The heating for hardening was done by suspending on wires in a cylindrical electric furnace made by the Leeds & Northrup Company, known as the hump type furnace.

Temperatures were measured on a single point recorder made by the same company.

Two temperatures were used in the experiment, 1440 and 1480, both temperatures being used for the water-quenched specimens and the 1440 temperature only was used for the oil-quenched specimens.

Four different times were used to bring the specimens "to heat," namely: 20, 30, 40 and 50 minutes. These times were very carefully controlled as well as the temperature by suitable regulation of the furnace and close observation of the temperature throughout the heating.

The results obtained from the treatments and measurements are plotted in Figs. 1 and 2, Fig. 1 showing the results following the water quench and Fig. 2 showing the results following the oil quench.

Examination of the curves in Fig. 1 brings out the following points:

Very rapid heating for hardening followed by a water quench causes the piece to elongate, the amount of elongation decreasing as the heating time is increased until a point is reached where no change in dimension occurs. This is shown by line No. 1. This has a possible application in that tools which are to be used for precision work or are of an intricate design may be hardened with little change in dimension and consequent lessened danger of breakage when the rate of heating is properly determined for the size of piece to be hardened.

It is also to be noted that the change in dimension is in the direction of rolling and advantage may be taken of this in the making of the tool, i. e., a slight undersizing of the tool in the direction parallel to the rolling where the ideal rates of heating are not maintained.

The tempering following the hardening causes the specimens to shorten, the amount of shortening being proportional to the tempering temperature, i. e., increasing as the temperature is increased. This is shown in lines 2, 3, 4 and 5.

Reannealing the specimens does not cause a recoverance of the original dimensions as might be expected. Line 6.

Rehardening following the anneal produces somewhat erratic results, although it was expected that there would be little change from the dimensions "as annealed" since the time of heating was 45 minutes where, according to the results noted in line 1, little change occurred in the original hardening (line 7). This discrepancy may possibly be due to an incomplete annealing and this idea seems borne out by the fact that the pieces which were hardened originally after a heating time of 50 minutes showed very little change in dimension after rehardening. Another possibility is that the type of anneal given the hardened pieces was dissimilar to the original anneal, setting up a new series of factors.

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These results indicate the inadvisability of reworking a tool after once hardening, especially if dimensions are to be closely maintained.

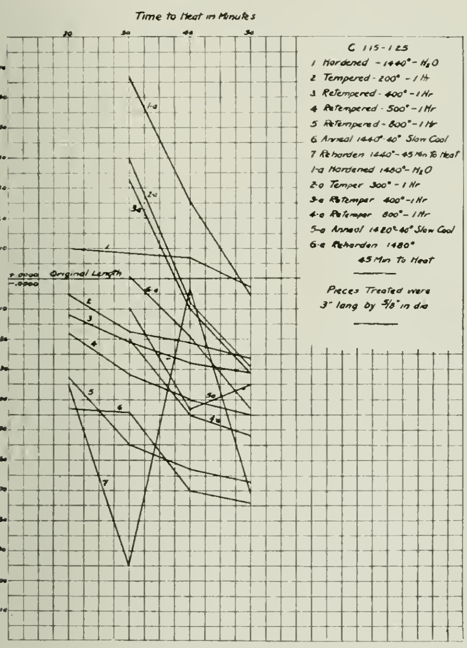

Fig. 1.

Hardening from a temperature of 1480 shows the same results as noted previously except that the amount of distortion is considerably greater. Shown in line 1-a. Lines 2-a, 3-a, 4-a, 5-a and 6-a follow the previously noted results except that line 6-a, showing the rehardening of the annealed specimen, is not so erratic.

It is again noted that the pieces originally hardened following a 50-minute heating showed a very little change from the annealed dimensions on rehardening.

The oil hardened specimens (Fig. 2) show a somewhat different behavior from the water quenched specimens in that all pieces were somewhat shortened after the quench in spite of variations in heating time and the tempering caused very little change in length, although the tendency is to shorten as the tempering heat is raised.

Rehardening following the annealing shows the same erratic behavior as noted in the water quenched specimens except in the case of the specimens originally hardened after heating for 50 minutes which showed very little change in length.

Summary.

There is a critical rate of heating for water hardening high carbon steel where there is no change in dimension. When this critical heating rate is exceeded the steel elongates in a direction parallel to the rolling and when the heating rate is slower than the critical rate, the steel shortens along the same axis.

Increasing the quenching temperature increases the amount of change when there is a deviation from the critical heating rate.

When the steel is quenched in oil the rate of heating has little influence on dimension change and the steel shortens along the axis of rolling.

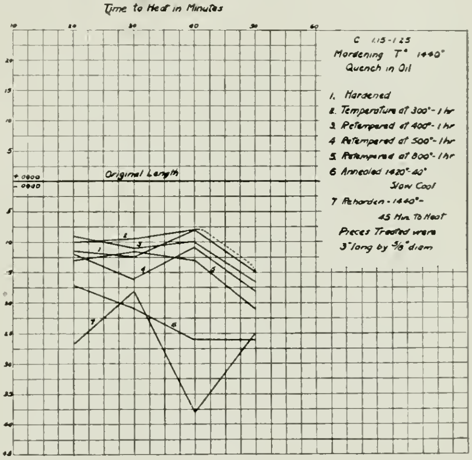

Fig. 2.

The original heating for hardening has a marked influence on the dimensional changes which take place on rehardening the same pieces.

Tempering shortens the elongated pieces, the effect increasing as the tempering temperature rises when the pieces are water quenched. This shortening action being almost negligible in oil hardened pieces.

The difference in behavior on tempering oil and water hardened pieces is probably due to the difference in structure following the quenching. The water hardened pieces contain mainly troostite. Tempering the water hardened pieces breaks down the austentite-martensite structure, precipitating the dissolved Fe_3C, causing marked change in dimension, while the troosite of the oil hardened pieces is relatively little affected by the tempering, the carbide not being in complete solution, and consequently there is little dimensional change.

A careful determination and regulation of the critical rate of heating for tools of various sizes and especially those of somewhat intricate design would permit of hardening them with little danger of breakage and practically no change in dimension, which would represent a considerable saving of labor in replacing tools broken in hardening and in the finish grinding of hardened tools with its attending danger of soft spots and grinding cracks.

Cleaning Producer Gas Made From Bituminous Coal

Pointing Out Reasons for the Assumption That It Would Be Too Costly from a Fuel Standpoint and Result in Gas Unsuitable for an Open Hearth Furnace to Clean Producer Gas

By HENRY W. SELDON, Met.Eng.
See-Seldon and Associates, Engineers

RAW producer gas consists of sensible heat, suspended matter, tar, tar vapors, condensible hydrocarbons, water vapor and fixed gas.

The fixed gas is that portion which the ordinary chemical analysis reports and represents what is commonly known as producer gas.

Clean gas is free from all suspended and condensible matter and in addition has lost its sensible heat.

Our researches into the causes of the deposits of soot, carbon, etc., in the mains, flues and checkers of an O. H. furnace have convinced us it would be necessary to thoroughly clean the gas before it is delivered to the mains in order to eliminate the deposit caused by the gas.

All the known methods for this cleaning will sacrifice the sensible heat of the gas in addition to the Btu value of the tar and volatile hydrocarbon which are being burned at present.

A conservative figure for this combined loss will be in excess of 20 per cent of the heating value of the coal.

The following discussion is given with the idea of pointing out if possible reasons for the assumption it would be too costly from a fuel standpoint and result in gas unsuitable for an O. H. furnace to clean producer gas.

Every book on the manufacture of steel treats of producer gas and much has been written on the chemical reactions taking place in the gas producer. Boiled down the following is an example of the reactions given:

(1) C plus O_2 equals CO_2.
(2) CO_2 plus C equals 2 CO.
(3) H_2O plus C equals CO plus H_2.
(4) 2 H_2 plus C equals CH_4.

It will be noticed that in the majority of cases only the fixed or permanent gas generated in the producer is considered, or in other words the gas which the ordinary sample taken and analyzed represents. If we will stop and consider the manner in which gas samples are taken we realize that the gas is being analyzed under conditions of temperature and pressure entirely different from the gas delivered to the furnace. Under present operating conditions the producer gas is sent from the gas house through the mains to the O. H. furnaces at a pressure of 1½" to 2" of water and at a temperature of 1,000 degrees (F.) or better. We take our gas samples directly from the above main with the gas under the above conditions with what effect? Our gas sample is at once chilled to atmospheric temperature and its pressure reduced to slightly better than atmosphere, with the result all the tarry vapors, condensible hydrocarbons and water vapors in the gas are condensed and deposited in the form of soot, carbon or water in the tube, then when we analyze the remaining gas in the tube we get what—only the analysis of that portion of the producer gas which remains gaseous at atmospheric temperature and pressure. Practically this analysis tells only half the story because the temperature and pressure of gas is not considered and the degree of saturation of the gas with the volatile products of the coal is not even hinted at.

Let us consider a hand fed gas producer operating satisfactorily and we will say ready for a fresh supply of coal which we add and attempt to analyze what takes place.

The reactions for the formation of the fixed gases are established, so we will surmise what happens to the volatile matter in the coal. The volatile matter is disengaged from the coal in the form of tar and condensible gases. The form in which the tar or condensible gases leave the producer will depend upon the operation and temperature of the producer and the quality of the coal. Recent developments in the byproduct coke industry indicate that the ratio of the oxygen and hydrogen content in the coal determine the kind of tar and by-products produced.

These products represent a considerable percentage of the heat value of the coal and often represents from 15 to 18 per cent. This is particularly true with hand operated coal feeders. Since we are at present burning a considerable portion of the above tar its presence in the gas at the furnace is shown by the accumulation of tar on the water cooled mushrooms and stems of the gas valves at the furnace. This condition becomes so pronounced at times it causes the valves to stick.

Because of the apparent simplicity of the reactions to form the standard producer gas analysis we are told you can make satisfactory O. H. producer gas out of any kind of coal, peat or lignite or in fact anything containing carbon.

If this is possible then why do the producer operators and manufacturers specify high grade high volatile coal for Open Hearth Producer Gas?

Aside from the difficulties of clinkering, high percentage of ash and slow burning of the poor grades of gas coal it is possible to make a producer gas which will show a socalled good analysis and still be unsuited for the O. H. furnaces.

The furnace man will say it is too thin or too light or too hot, so what is the answer? There must be something lacking from this gas which is present in another gas and yet in neither is it shown in the analysis. Actually it can be five variables which the analysis may not show namely, moisture, temperature, pressure, tarry vapors and condensible hydrocarbons. Moisture may be due to water leaking into the producer or the mains or to too much steam. Temperature may mean sensible heat or apparent dryness or stickiness of the gas. But usually the difference between good satisfactory producer gas and unsatisfactory gas is due to the percentage and form in which the tarry vapors and condensible hydrocarbons furnish present in the gas. Unfortunately their presence has the undesirable feature of causing a deposit of soot in the mains and flues. This deposit begins accumulating in the producer and is a gradual formation over the entire course of the gas until the zone of combustion in the furnace is reached. Here the balance of the tarry vapors and condensible hydrocarbons are a material increase in the Btu value of the gas in addition to imparting visability, weight and heat radiating value to the entire flame.

Dependent upon the working of the producer a small percentage of the sewer deposit is caused by suspended coke and carbon carried by the velocity of the gas but this portion is usually taken out by the first dust catchers.

Regarding the blocking up of the gas and air checkers in an O. H. furnace our observations have led to some interesting conclusions.

The amount of deposit in the gas and air checkers appears to be dependent upon the length of time the furnace has been in operation and the character of the fuel used. Analysis of the deposit found in the checkers of an O. H. furnace using tar as fuel is as follows:

Ferric Iron	(Fe_2O_3)	94.00%
Ferrous Iron	(FeO)	None
Silica	(SiO_2)	3.30
Carbon	(C)	.25
Alumina	(Al_2O_3)	Undetermined
Lime	(CaO)	"
Magnesia	(MgO)	"

The amount of this deposit compared to the deposit on similar runs on natural gas we would estimate to be an increase of at least 50 per cent. The analysis and appearance of the deposit indicate it has been carried in suspension by the burnt or burning gases from the furnace and is dropped in the checker chambers when the velocity of the gases change. The amount of deposit is greater on top of checkers and gradually diminishes toward the rider walls.

The variation in the amount of deposit in the checker chambers appears also to be governed by the velocity and density of the products of combustion of the fuel used.

We had the following analysis made from the checker deposits found in a producer gas furnace from both the gas and air chambers.

	Air Checker Deposit.	Gas Checker Deposit.
Fe_2O_3	82.85	51.20
Al_2O_3	1.70	9.75
SiO_2	7.45	31.25
CaO	3.15	4.00
MgO	3.75	2.75
Mn	.65	.75
Carbon	.45	.30

These analysis indicate the nature of deposit in each case is chemically the same but physically the two deposits vary and we believe the difference is not due to any carbon deposit on the gas checkers but to the relative difference in specific gravity of the deposits.

Due to the baffling effect of the checkers to the incoming producer gas undoubtedly some tar is deposited on the face of the brick and in addition some carbon is released due to a breaking up of the CH_4 in the producer gas. CH_4 is unstable at temperatures above 1,000 degrees (F.) and under certain conditions is broken up to form C and $2H_2$. This is shown by the analysis of gas taken after the gas leaves the checkers being higher in hydrogen and lower in CH_4. This is the principle reason natural gas is not preheated. However the carbon so released is not necessarily deposited; we believe it is carried along with the gas and materially enriches the gas.

However in the case of producer gas it is more economical to pre-heat the gas and discount any loss on account of the breaking up any CH_4.

We will therefore assume that the gas has been on the one end of a furnace for 15 minutes and it is time to reverse the direction of flow—at this time as indicated by our deductions we possibly have a deposit of carbon and tar on the surface of the bricks in the gas chamber. Then consider what happens after we have reversed the furnace. The products of combustion from the furnace are now passing through the gas checkers (also the air) at a temperature of 1,800 degrees to 2,200 degrees (F.) with an excess of oxygen from .2 per cent to 15 per cent and with the result of tar and carbon deposit is burned to CO_2 plus H_2O and only oxidized products of iron silicon and calcium remain, as shown by the analysis of the gas checker deposit.

Water cooled ports have a tendency to chill the products of combustion and cause some of the suspended particles in the burnt gases going to the gas checkers to be dropped in the port. This may be one of the causes why the amount of deposit has been greater in the air chambers than in the gas checkers of the furnaces which have been taken off for repairs.

In our investigation of the possibilities for washing producer gas we found the following methods available and in operation but did not find evidence of gas being washed for O. H. furnace use.

The Flinn & Dreffein Clean Bituminous Gas equipment can be used for cleaning gas from any style of producer. The equipment consists of:

Gas Cooler
Tar Extractor (Primary and Secondary)
Scrubber
Gas Exhauster.

The gas cooler consists of a circular steel tank through which the passing gas is brought in contact with sprays of water. Here the gas is partly cooled and much of the soot, dust and heavy tars are thrown down.

The Tar Extractor is patented and removes the tar by utilizing the impact principle and precipitates the tar by the repeated impinging of the gas upon zig zag surfaces. A small quantity of water is used and the gas is further cooled.

The Scrubber is also a cylindrical tank and is fitted with board checker work and sprinklers. This apparatus is designed to further cool the gas and remove the last particles of dust that it may contain.

The Gas Exhauster is of the high pressure positive rotary type and is usually operated at a constant speed.

The Smith Gas Engineering Co. Producer Gas Cleaning Equipment is essentially a filtering proposition.

The equipment consists of:

Primary Condenser
Gas Exhauster
Tar Extractor
Secondary Condenser.

The primary Condenser is a cylindrical tower filled with baffles sprayed with water from the top. The gas is partly cooled and some of the heavier impurities removed.

The Gas Exhauster or pump is supplied for steam or motor drive.

The Tar Extractor is supplied with multiple heads in which the grating and glass wool filter is located. The heads are so arranged it is an easy matter to cut out one for cleaning.

The Secondary Condenser is similar to the primary condenser and cools the gas at atmospheric temperature.

This method of cleaning is only recommended for Smith Gas Producers where the volume of tar in the gas is low and as they state does not represent over 5 per cent of the heating value of the coal. As the volume and quality of the tar fluctuates the efficiency and ease of cleaning also fluctuates. A large number of installators have been made in small heating plants and glass works.

The Camden Iron Works Clean Gas Plant Equipment consists of a centrifugal tar extractor which used about 6 gallons of water per 100 cu. ft. of gas required and delivers gas clean enough for gas engine purposes. The objection to this method of cleaning producer gas appears to be in the disposal of the emulsion of tar and water and has been the cause of several plants discontinuing its use.

For washing large quantities of gas they recommend the Theison Washer.

A similar type of rotary scrubber is manufactured by the Buffalo Forge Co. and we understand is being successfully used. The gas is first sprayed in a cooling tower where temperature is reduced from 1,200 degrees (F.) to 100 degrees (F.) and suspended matter and heavy tar is removed. The gas is then sent through the scrubber and finally through a precipitator to remove the moisture. The tar is reduced to .015 grains per cu. ft.

Two Electrical Precipitation Processes are available for cleaning Producer Gas:

(1) Cottrell Electrical Precipitation.
(2) Steere Engineering Co. process.

The Cottrell process uses direct current and the Steere alternating. Both processes require a preliminary cooling and washing of the gas in order to make the cleaning efficient and under favorable conditions both processes claim to deliver a clean gas. The last 5 per cent of tar in the gas is the most difficult to remove. The principle difficulties which arise are insulation problems and accessibility of cleaning. Duplicate units are recommended to insure continuous operation. In order to free an O. H. plant from the condition of having deposits in the gas main and flues it would be necessary to completely clean the gas. This is entirely possible, the expense of washing is not prohibitive and we have the choice of several different methods which are in use at the present time. However we do not find evidence or sufficient reason to clean producer gas except where it is absolutely necessary before the gas can be used such as for gas engine use or where the point of consumption of the gas is far removed from the gas producers. Open fired annealing furnaces at glass plants require clean gas account spotting the product.

On the other hand we are convinced the Btu losses incidental to completely cleaning bituminous producer gas makes the process too costly. Also we feel sure washed producer gas would be entirely unsuited for O. H. furnace work.

The following calculation shows the per cent sensible heat loss which would result in cooling producer gas to atmospheric temperature.

Average Gas Analysis:

CO_2	6.0
C_2H_4	.2
O	—
CO	20.0
CH_4	3.5
H	11.0
N	59.3
Btu	**140.**

Temperature of
Producer Gas at G. H. — 1250 degrees F.
Temperature of
Producer Gas at Furnace 950 degrees F.
Temperature of
Atmosphere (Assume) 50 degrees F.

$90.3 \times .0196 \times 900$ equals 1,592.89 Btu
$6.0 \times .0293 \times 900$ 158.22
$3.5 \times .0299 \times 900$ 94.19

Total heat loss per 100 cu. ft. 1,845.30 Btu
Total heat lost per 1 cu. ft. 18.5 Btu

$$\frac{18.5}{140 \text{ plus } 18.5} \text{ equals } 11.6\% \text{ sensible heat loss.}$$

STEEL MEN HAVE MEETING.

Charleston Chapter of the American Society of Steel Treating held its regular meeting Tuesday evening, November 18, at 8 o'clock at Hotel Ruffner, and had present National Secretary W. H. Eisenman of Cleveland, Ohio, whose subject was "Heat Treating: Its Past, Present and Future." J. E. Arthur presented the first paper of the evening. His subject was "Steel Melt Shop Practice." The chairman of Charleston chapter extends an invitation for all interested in steel and its treatment to attend any meeting.

The regular monthly meeting of the Pittsburgh Chapter of the American Society for Steel Treating Tuesday, November 1, was addressed by Frederick Crabtree, Professor of Metallurgy, Carnegie Institute of Technology. His subject was "Absorption of Sulphur During the Heat Treatment of Steel." Mr. N. B. Hoffman also made a report on "Impressions of the Indianapolis Convention."

Manufacture of Wire for Wire Rope

A General Description of the Methods Used in Manufacturing Wire for Wire Rope

By CURTIS VOIGTLANDER,* M.E.

SO LITTLE has been published and so little is apparently generally known about the manufacture of wire, that a description of the usual operations of this important branch of the steel industry should be quite acceptable.

The steel used for rope wire is usually the best acid open hearth steel and varies in carbon content from .30 per cent to .80 per cent according to the grade of wire to be manufactured.

As the rolling of billets and of wire rods has been frequently described in technical journals, we will start with the rods delivered to the wire mill, and show how the wire is manufactured.

No. 5 BWG is the smallest rod that can be rolled with a fairly circular section.

The No. 5 rods in coils weighing from 150 to 250 pounds are delivered to the tempering or "patenting" furnace of the wire mill and placed upon the reels or "swifts" to allow uncoiling.

The furnace is from 30 to 60 feet long and is fired with coal, oil or producer gas. The rods are run through the furnace, where they are heated to from 1400 deg. to 2000 deg. F. Then out into the air and on to the revolving iron drums or "blocks," which wind up the rods, pulling them through the furnace.

Both the temperature of the furnace and the speed of the blocks are regulated according to the size of the rods or wire, and according to the carbon content of the steel, so as to give the best "temper," as determined by long experience. If an exceptional strength is wanted, the rods are often cooled more quickly on coming out of the furnace by running them through a pan containing melted lead. This is the so-called "lead tempering."

The tempered rods are next pickled in the cleaning house in dilute sulphuric acid to remove all the scale. They are washed and dipped into a lime bath to neutralize the acid and to prevent rusting while drying.

The rods are then dried in a dryer for several hours at a temperature above 212 deg. F. When thoroughly dry they are pulled out and placed at the swifts of the wire drawing benches.

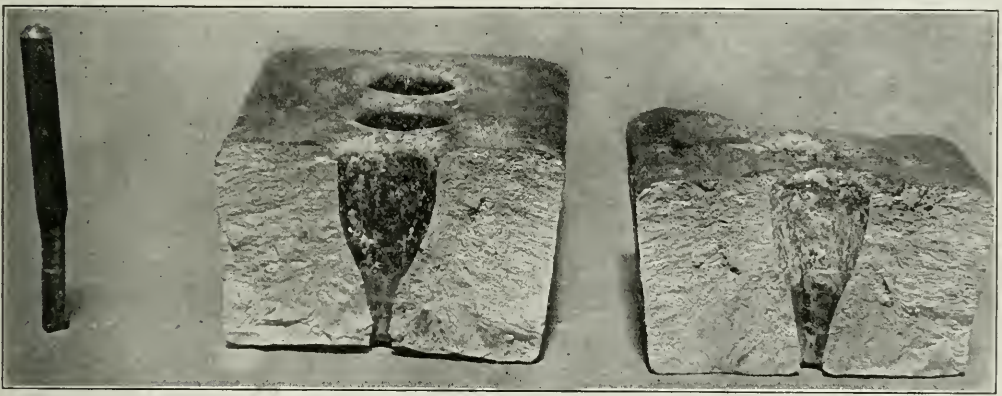

Fig. 1.

The wire drawing blocks are very similar to those on the pull out frame of the tempering furnace, except that they are heavier, and each one has a clamp at the top. After the coil of rod is placed on the swift and the end pointed by means of a special pointing machine, the end is inserted through the hole of the cast iron die, and a few feet of wire drawn through by means of a pair of traveling tongs. The die is fastened in a suitable stand in front of the block with a compartment in front of it for powdered soap, which lubricates the rod or wire as it enters the hole. The end of the wire just pulled through is clamped fast to the top of the block, and the clutch is kicked in. The block revolves and as it winds up the wire, pulls it through the die, reducing the wire to the diameter of the hole and lengthening it proportionally. This operation is repeated through a smaller hole in another die in front of the next block, etc., until in from three to seven or more reductions or drafts, the rod is reduced to a predetermined size. If the required size is large enough to be drawn from then worked cold, the tapering hole punched with a hardened steel punch and reamed or "set" to size with the rod, no further treatment is necessary, and the coil is called "finished wire." This is then weighed and carefully tested for breaking strain, bending, torsion, elongation, etc., and is ready for the rope shop.

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*The author is with the George C. Moon Company, Garwood, N. J.

The holes in the dies are made by a die reamer, a man long skilled in his work, as the holes have to be perfectly smooth to make smooth round wire. The holes have a gradual taper ending in a cylindrical section. The sizes resulting from each draft are carefully calculated in advance to obtain the required properties of the wire.

Fig. 1 shows two sections of a cast iron die broken in half to show the shape of the hole. A piece of wire which has been pulled through the die, cut off and pulled back out of the hole, is also shown.

Drawing wire hardens and strengthens it, until a point can be reached where it becomes brittle. Consequently, there is a limit to the size that can be finished right from the rod. When finer sizes are to be drawn, the wire from the first drawing is again put through the tempering furnace, where it regains its elasticity and is softened or tempered. The usual cycle of pickling, drying, drawing and testing is then repeated.

In drawing the medium and fine sizes of wire, the cast iron dies are rarely used for many reasons, the chief one being that it is more difficult to ream accurate holes of the finer sizes.

Steel plates or wortles are used, which have the holes punched hot to the approximate size. These plates are a hardened steel "set."

The operation of drawing wire gradually enlarges the hole so that the last end of the coil of wire may be 1/1000th inch larger than the front end.

In cast iron dies the hole must be reamed to the next larger size until finally the hole becomes so large that the die must be discarded and remelted to make a new batch of dies.

The plate or wortle, however, being elastic steel, is hammered all round the back of the hole, closing it up a few thousandths of an inch. It is then again punched to shape and reamed or set to size as before.

Still finer sizes of wire must be drawn through still harder steel plates, usually made of chrome or tungsten steel.

The extremely fine sizes are drawn through a hole made in a diamond, the hardest substance known. The reason for this is that the fine wire is so tough and unyielding that a hole made in the hardest of steel dies would not last long, and it is very difficult to make this hole except with the most delicate and accurate instruments.

Cast iron dies have from three to 16 holes according to the size of the die.

Steel plates are usually punched with three rows of holes, six holes to the row.

A wortle is a small plate punched with one row of from two to seven holes.

Diamonds are, of course, very small, and have only one hole. The diamond is usually set in a circular brass disc about the size of a quarter and four times as thick.

Foreign Methods of Roll Design[*]

English Roll Turners Follow Rule of Thumb Methods Rather Than Theory—Results of Investigations Made by America and Germany in Roll Design.

By R. H. RONNEBECK, B.Sc.

IN DESIGNING a set of rolls, it is our object to convert a rectangular ingot into the finished section in the least possible time and with the least possible expenditure of energy. It is done in three stages—cogging, roughing and finishing. We have to decide the number of passes, the amount of reduction in each, and the arrangement of the passes on the rolls. It is generally desirable to use as few passes as possible with a view to saving time, but an exception to this is often made when it is desired to use the same roughing rolls for two different finished sections. Saving in time means that the bloom has less time to cool, and is, therefore, softer and easier to roll; it also means greater output.

In cogging, the reduction at each pass is generally limited by the diameter of the rolls.

Figure 1 shows the deciding factors as to whether the ingot will be drawn into the rolls or not. The critical condition occurs when the resultants of the frictional forces F and the radial forces P are vertical. The critical angle A differs according to various authorities. Karl Lang, a Hungarian writer, gives A 35 deg. for roughened rolls. Hirst gives A 30 deg. while Geuze gives A 22½ deg. The last named is equivalent to a reduction of one-thirteenth of the diameter of the rolls. Dehez states that the higher the temperature of the bloom, and in the case of first forming passes, the sharper the V shaped grooving of the bloom, the better the rolls will take hold.

A common method is to start from the desired finished section and work back to find the proper size of bloom to which the ingot must be cogged. Some skilled designers prefer to select the size of bloom by judgment, and then design the following passes so as to gradually approach the finished section.

Design of Cogging Rolls.

A great amount of latitude is permissible in designing cogging rolls. The sizes of the largest ingot

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[*] Paper read before Cleveland Institution of Engineers, Middlesbrough, April 4, 1921.

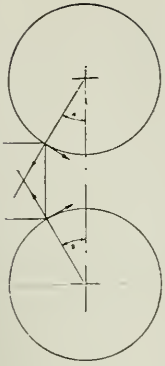
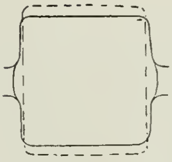


Fig. I



Formation of Fin on Bloom.

Fig. 2

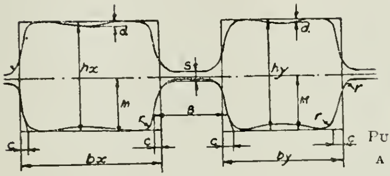
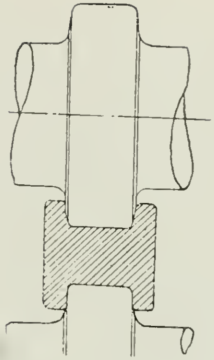
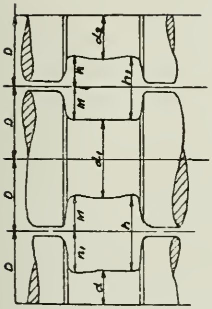


Fig. 3



Puppe's 1st Forming Pass preparing a Bloom for his Universal Mill.

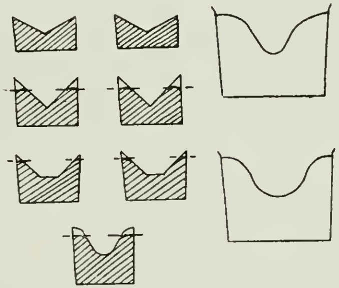
Fig. 9



$$M = \frac{h+h_1}{4}$$
$$n = \frac{3h_1 - h}{4}$$
$$n_1 = \frac{3h - h_1}{4}$$
$$d_1 = D - \frac{h+h_1}{2}$$
$$d_2 = D - \frac{3h_1 - h}{2}$$
$$d = D - \frac{3h - h_1}{2}$$

Billet Rolls for Three-High Mill.

Fig. 4



Calculated and Actual Filling of Holes

Good and Bad Types of 1st Forming Pass

Fig. 5

and the smallest bloom must be taken into consideration. It is often desirable to be able to roll slabs, and this limits the depth of the widest groove. The actual amount of reduction is generally given by screwing down the top roll.

The reason for the increased diameter of the rolls in the centres of the grooves is shown in Fig. 2. When a bloom is rolled with a heavy reduction, the sides bulge out. This would cause the bloom to "fin." By making the sides concave to start with this is avoided.

This Figure is copied from Hutte, and gives the proportions of the cogging roll grooves for a two-high reversing mill.

Fig. 4 gives the same for a three-high mill.

The roll diameters in the case of a two-high mill may be equal, or the bottom roll may be made a little larger, say ¼ in. to ⅝ in. with a view to protecting the roller trains. The slightly larger bottom roll caused the bloom to be curved upwards, especially at the ends. The bloom will not strike the rollers with such force if this is done.

After being cogged down to a suitable rectangular section the bloom has its rough ends sheared off and then enters the roughing mill. Here it is given a shape approaching the desired finished section. There is no hard and fast line between the roughing and finishing stages. The first forming pass, as its name implies, is the pass in which the bloom departs from its rectangular section. There are many different ways of roughing and finishing a given section, which I will deal with further on. There are certain definite principles connecting the shape of the first forming pass, and the rectangular bloom which is to enter that pass. As these principles hold good in the following passes, I will deal with them now.

For all commoner sections, such as channels, joists and rails, the first forming pass necessitates rolling a groove in either the top or both the top and bottom sides of the bloom. It is in this pass that the heaviest reduction and the greatest change of shape can be given. We, therefore, require to know the limiting factors governing the size of groove we can successfully roll in the bloom. It is obvious that the centre of the bloom is more heavily reduced than the side portions. The elongation must be proportional to the reduction provided that no metal flows out sideways. What actually happens is that all the parts undergo the same elongation. Tafel, a German engineer, found from a series of experiments that the actual elongation in any pass was the mean of the elongations which the various parts of the section would undergo if they were not connected together. That is, the central portion in the case we are considering is held back by the outside portions, and the outside portions are dragged out by the centre. To equalize matters a certain amount of flow takes place from the centre to the outside. We must design the shape of the groove to facilitate this flow if we wish to economize in power. The figure shows a good and a bad form of groove. You will see that in the bad form a large amount of metal must flow suddenly from the heavily reduced centre to the sides of the section. If we attempt to roll too large a groove, the elongation will be so great that the hole will not be filled at the sides. The following method of finding to what height the hole will be filled is due to Tafel, and is based on the experiments I have just mentioned.

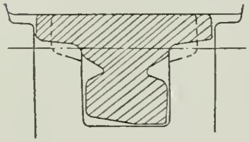

Swabbing Hole
For Spreading Flange of Rail.

Fig. 7

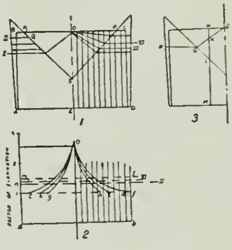
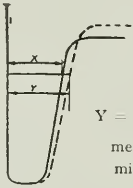


Fig. 8

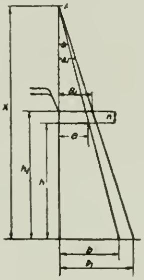
Suppose a bloom of section A B C D is to enter a hole as shown on the figure. The bloom is divided vertically into a number of equal parts. The theoretical factor of elongation of each part is plotted in the figure below. The portion of the section outside the points P_1 and P receive no roll pressure and the ratio of original to final length is, therefore, unity, which is represented by the height, a 1 in the diagram. At the point O the section is reduced to S. The corresponding elongation factor equals E O divided by E S, which is 2.57. This gives us the point O on the lower diagram. Points between S and P are similarly treated, and we get the curves O C and O d. Now the mean elongation factor is the mean height of the area a 1 C O d f b. This mean is the height a m and according to Tafel's law is the actual elongation factor of the whole section. We therefore draw R Q so that the area A R Q S E multiplied by this elongation factor equals the area A B O E. But this cannot be the correct filling of the hole, because we started with the assumption that the section from P_1 to P was under roll pressure. Looking for a moment at Fig. 2 you will see that the section at H is reduced to L. Now assuming that R Q is the actual filling of the hole and joing O Q, we divide the reduction into two parts. H K represents the reduction due to the extension of the bloom by the centre part and K L represents the reduction by actual roll pressure. We are at present only concerned with the latter. Turning back to Fig. 1 we have just found that the bar is under pressure only from S to Q. We, therefore, plot a fresh curve of values of K M divided by L M, giving us the figure a 1 g O h f b. The mean height is a n. From this we draw a second level marked II so that the area enclosed multiplied by the mean height a n is equal to the area A B O E. Again, this cannot be the correct filling, because it shows that the roll pressure is exerted over a different width to what we have assumed. But if we repeat this process a few times we will finally obtain a level marked VI, which is correct. Now this, you will say, is a very tedious process, but by estimating the level as nearly as possible in the first place, we can easily check it by this method, and so eliminate much of the work. I have described it in full so as to demonstrate the principle involved as clearly as possible. In practice the lower diagram can be dispensed with by simply tabulating the values $\frac{K\ M}{L\ M}$ and finding their arithmetic mean. With the aid of a planimeter the problem only takes a few minutes.



$$Y = X\left(1 + \frac{X^2}{200}\right)$$

measured in millimeters

Fig. 11—Reduction in closed hole.

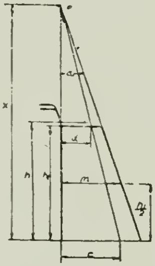


Given h tan α a b Q (area)
n = 5mm. (constant)

1. $X = \frac{b}{\tan \alpha}$
2. $h_1 = h + n$
3. $\tan \alpha_1 = \tan \alpha \ (1 + \tan \alpha)$
4. $a_1 = (X - h_1) \tan \alpha_1$
5. $b_1 = X \tan \alpha_1$
6. $Q_1 = h_1 \frac{a_1 + b_1}{2}$

3a. $\tan \alpha_1 = \tan \alpha \ (1 + \frac{\tan \alpha}{2})$

Fig. 12—Design of open hole for flange or joist.



Given h tan α d c Q_1.
(Q_1 is the same as found for the corresponding open hole.)

7. $h_1 = h - \frac{1}{2}$ to 1mm.
8. $m = \frac{Q_1}{h_1}$
9. $\tan \alpha_1 = \frac{m}{X - h_{1/2}}$

Fig. 13—Design of closed hole.

This method is correct, no matter what the shape of the groove, provided that the angle at the bottom is not less than 50 deg. or 60 deg. With a sharper groove a certain amount of cutting takes place, and the hole is filled more than the calculated amount.

If the hole is wider than the bloom in order to allow for spread, it will, of course, not be filled so high. This can easily be allowed for by multiplying the mean value of $\frac{K\ M}{L\ M}$ by the width of the bloom, and dividing by the mean width of the hole.

The previous figure shows how accurate the method really is. The full line shows the actual filling, and the dotted line the calculated amount.

When the bloom is grooved on both the top and the bottom, it is only necessary to divide the section in half horizontally and then to proceed as above.

This method can also be used in the design of swabbing passes for rails and T bars. A swabbing pass is a pass in which only a part of the section is given any reduction. The reduced part cannot elongate because it is restrained by the remainder of the section. It is, therefore, compelled to spread. The figure shows how this is utilized to form a wide flange on a rail. Swabbing passes should be used as little as possible, because no work is done on the bulk of the section, and it cools considerably. I would point out here that the work done in rolling a bar is converted into heat, which materially assists in keeping up its temperature.

Now a few words on that bugbear of the roll turner-spread.

When any section is passing through the rolls it not only elongates, but widens. This increase in width is called spread. Very many attempts have been made to reduce spread to a mathematical formula, but so far without complete success. Geuze in his book on the "Rolling of Iron and Steel," published in 1900, gives a graphical method of determining spread. But under certain conditions, his method gives negative results, which are, of course, impossible. Further on in his book he ignores this method, and simply says that spread is equal to .48 of the draught for iron and .36 of the draught for steel. This is also correct in certain cases.

It has been found by experiment that spread depends on the draught, the diameter of the rolls, and the temperature of the bloom.

Brovot's formula neglects the diameter of the rolls, and cannot, therefore, be correct.

Ernst Scheld and Adolf Falk agree in stating that the temperature of the bloom has no effect on spread. They say that springing of the rolls under the higher pressure caused by a cold bloom accounts for the apparent effect of temperature. Scheld gives a formula

$$\text{Spread} = \frac{d}{50}\cot.\alpha \qquad \text{Kirchberg.}$$

$$\text{''} \quad = \frac{A\,d\sin\alpha}{h_1} \qquad \text{Scheld.}$$

$$B = \sqrt{\frac{9.23\,d\,b\,(h_1 + h)}{h_1\,\beta} + b^2} \qquad \text{Falk.}$$

Where b = width before pass. B_1 = width after pass.
h = height before pass. h_1 = height after pass.
d = draught = $h - h_1$. α = arc of contact in degrees.
β = arc of contact for $h_1 = O$ (rolls closed).
A = length of arc α.

COMPARISON.

					Kirch-berg.	Scheld.	Falk.
24-in. Mill							
h=120	h₁=100	b=100	α=14.7°	b₁=	101.5	104.0	105.4
120	100	200	14.7°	"	201.5	204.0	205.4
60	50	100	10.4°	"	101.1	102.0	103.9
60	50	200	10.4°	"	201.1	202.0	203.9
36-in. Mill							
120	100	100	12 °	"	101.9	104.0	106.6
120	100	200	12 °	"	201.9	204.0	206.7
60	50	100	8.5°	"	101.3	102.0	104.8
60	50	200	8.5°	"	201.3	202.0	204.7

Fig. 9.

which, invariably does not work out correct. Falk claims that his formula

$$b_1 = \sqrt{\frac{0.161\,d\,b\,(h_1 + h)}{h_1\,\alpha} + b_2}$$

where b_1 = width after the pass
b = width before the pass
h_1 = height after the pass
h = height before the pass
α = arc of contact in radians with rolls closed.
d = draught = $h - h_1$

covers every case that he has tried. He also agrees with Scheld that spread is independent of the nature of the steel and speed of rolling as well as of temperature. Numerous tests at different temperatures all gave the same result. But it is pointed out that the case is quite different if the temperature of the bloom is uneven. This would be the case if the bloom were allowed to cool in the open. The inside would be far hotter and softer than the outside. The harder shell would offer great resistance to elongation, but not a greatly increased resistance to bulging at the sides. The result is that the spread of a chilled bloom is greater than if it were at an even temperature throughout.

Most authorities agree that spread is independent of the initial width of the bloom. Falk's formula does not agree with this as you see, but the effect of "b" in the formula is very small. This formula is not merely rule of thumb, but it is the result of a long and elaborate mathematical process based on first principles.

Tafel has evolved what he calls the "Depth Influence Theory." He finds that spread only affects the bloom to a certain depth from each side. Hence the name. This theory is very similar to Falk's, except that he considers that every part of the cross-section of the bloom except the vertical centre line, contributes to spread. Tafel considers that there is a central area which contributes nothing to spread, but all to elongation. Tests appear to substantiate Tafel's idea, but the real difficulty is that there is no means of calculating this depth, so this theory hardly carries us any further.

$$\text{Spread} = \left\{\frac{2\,E - e\cot A + \beta}{100 \qquad\qquad 2}\right\}$$

which simply means that spread equals one-fiftieth of the draught multiplied by the cotangent of the angle of contact with the rolls, but he admits that this is only approximate. He uses it in his examples of joist and channel passes drawn at the end of his book.

Dehez, a man who devoted his life to the study of rolling, does not agree with Falk and Scheld that temperature has no effect on spread. In order to ensure the complete filling of "closed holes," he allows a spread of .25 to .3 of the draught.

W. Trinks, an American professor, has written many articles concerning roll design and spread in "The Blast Furnace and Steel Plant," to which I must refer you for further particulars.

The fact is that most of the formulae for spread give fairly accurate results for the range of conditions which

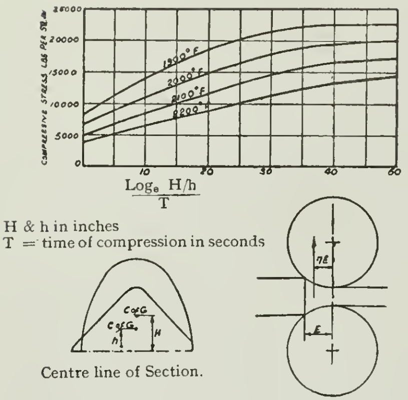


Fig. 10

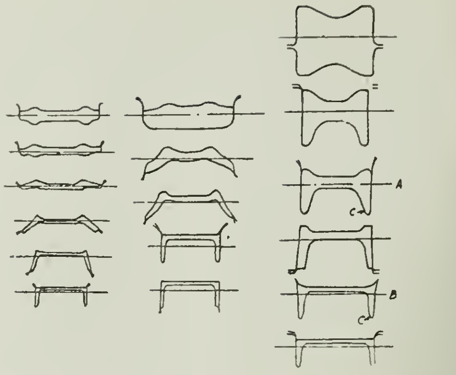
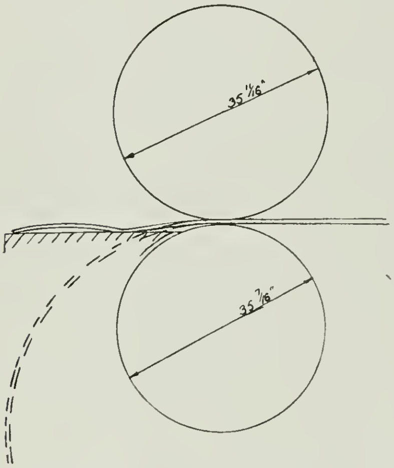


Fig. 4. Sample passes "bending-up" method of rolling channels.

Fig. 6–Sample passes combination method of rolling channels.

Fig. 5–Sample passes "counter" flange method of rolling channels.

Fig. 16



Wavy Rolling of ½in. Flat in 36in. Mill.

Fig. 17

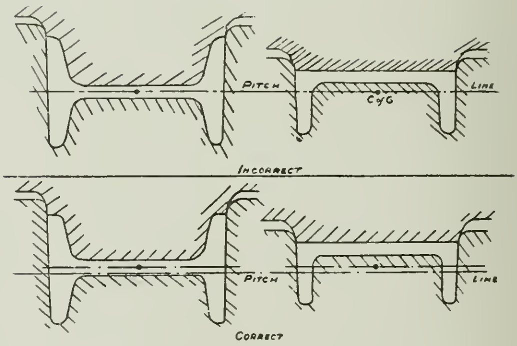


Fig. 18

they are intended to cover. They fail when applied outside these ranges.

I now propose to deal with the actual design of rolls for joists.

We must begin by choosing the maximum possible reductions. We are not tied to the rule of proportional elongation in the earlier stages of roughing. Steel will stand an enormous amount of distortion provided it is of good quality and above a certain temperature. Puppe demonstrated this in rolling blooms which were to be finished in his famous universal mill. This slide shows his design. You will see that the web is enormously elongated, and the flanges are simply dragged along with it. In spite of the predictions of failure of many roll turners, this design was quite successful, and no cracks developed in the bar. Incidentally it is interesting to note that no collars are required to ensure that the bloom remains symmetrically between the rolls. I suggest that the action of the rolls on the bloom is in this respect similar to that of the crown of a belt pulley on a flat belt.

In finding our maximum reduction we have to consider the strength of the rolls as regards bending.

The next figure shows the pressure per square inch of projected area of contact between the bar and the rolls.

The stress in the rolls follows the usual formula:

$$f = \frac{M}{Z}, \text{ Z being the section modulus.}$$

For steel $Z = \frac{1}{10} d^3$, but for cast iron it is $\frac{1}{10} d^3$ because cast iron does not follow Hooke's law. The strength of a roll depends largely on the radius of the fillet at the bottom of any grooves in it. To allow for this the stress "f" must be multiplied by 10 for a sharp corner, by 3 for ¼ in. radius, 2 for ½ in., and 1½ for 1in. radius. Trinks recommends a factor of safety of 3, which is equivalent to a drop in temperature in the bloom of 350 deg. F. below the normal. For cast steel rolls he gives a yield point of 40,000 lbs. per sq. inch, and 75,000 lbs. per sq. inch for forged nickel steel. For cast iron rolls the limit he assigns is 25,000 to 28,000 lbs. per sq. inch. I believe there would be fewer breakages of rolls if this calculation were carried out in all cases where sufficient strength is doubtful.

The rolls must also be strong enough to withstand the torque which can be estimated from the assumption that the centre of pressure between the bloom and the rolls occurs as shown on Fig. 10. To this must be added the friction of the roll necks. This total must, of course, not exceed the maximum driving torque. It is also assumed that the housing will stand the strain .

In practice the reduction is generally limited by the fact that the rolls will not bite if too much is attempted, especially is this the case in the cogging mill.

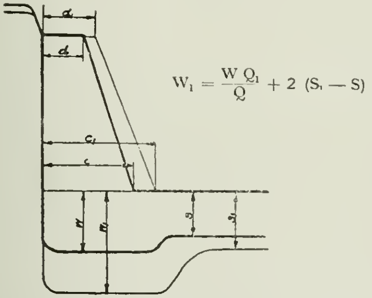


Fig. 14—Proportions of counter flange for channel pass (Kirchberg).

An American firm carried out experiments a few years ago in order to ascertain the best arrangement of reduction passes in the cogging mill. They found that the best results were obtained by commencing with a small reduction and increasing it gradually to a maximum in about five passes. The bloom was then tilted, and the same treatment repeated. This method was very effective in preventing the formation of cracks. The reason given was that the steel was only subjected to severe deformation after the grain had been broken down small. Once this had been done the reductions gradually decreased as the temperature fell. Kirchberg is very strongly in favor of decreasing the reduction factor in such a way that it follows a parabolic law. His method of designing passes for joists and channels is worth describing. He bases it on the tangent of the angle of the finished flange combined with a parabolic formula, and he works back from the finished section. The use of the parabola allows for the fact that the plasticity of the steel decreases with the thickness and with the temperature. As he starts with the finished section he talks about the "increase" and "coefficient of increase" instead of about reduction. The coefficient of increase must be the same for both web and flanges for any one pass. The deciding factor is the closed hole which must be designed within 5 per cent limits. The figure shows the formula used and its application. In the right hand figure both top and bottom must be regarded as closed holes. In passes with open holes the flanges can be given a heavier reduction, up to twice as much as for closed holes.

The next two figures show the methods of designing open and closed holes for joist and channel flanges. The cross-sectional areas Q_1 for any one pass must be equal and closed holes alternate with open holes. The web is given the same reduction in area as the flanges and spread is allowed for by using Kirchberg's formula given on Fig. 9. For the last hole but one, i. e., the first hole to be designed equation (3) of Fig. 12 is modified to (3a). The formation for the closed hole remains the same.

After the consideration of joist flanges, channels involve nothing new, and the same formula can be used. But to avoid a too rapid cooling of the corners (owing to no work being done on them) what is known as the "counter flange" is used.

Fig. 15 shows this and gives its proportions.

Having determined the chief dimensions of the passes it only remains to round off the corners.

This figure shows how this is done, and also gives the necessary taper of the holes.

You will see from the formula $y = X\left(1 + \frac{X^2}{200}\right)$ that if the finished flanges are to have straight sides, all preceding holes must have more or less parabolic sides. The distances E and E_1 are therefore marked off according to the formula $E = \frac{b^2}{200}$ and $E_1 = \frac{c^2}{200}$. From these points A and B parabolas A F and B F_1 are drawn tangential to the flanges. For this Kirchberg uses a French curve cut to a parabola having the equation $x^2 = 10y$ drawn in centimetre units. For open holes the apex A is placed tangential to the flange so that the curve runs through F, and for closed holes the point B is tangential to the flange.

For channels R is the same as for joists, but the other radii must be made somewhat smaller.

The method outlined above can generally only be used up to and including the 7th hole. Beyond this the draught may easily be too great for the roll diameter. The remaining holes can be calculated from the following formula:

Given h_1 a_1 $\tan \alpha_1$, b_1

$$h_1 = h \; 5\text{mm}$$

$$a_1 = a \, \frac{a^2}{200}$$

$$\tan \alpha_1 = \frac{a_1}{X - h_1}$$

$$b_1 = X \tan \alpha_1$$

Widening E, rounding off and tapering (s) is done as in the previous holes.

The method can be used for more holes in the case of channels than for joists because of the smaller taper of the flanges. But in order to avoid using too great a number of passes X should be shortened by 10 per cent when calculating a closed hole from an open one.

There are two other methods of rolling channels. The "bending up" method, and a combination of bending up and counter flange. Fig. 16 which has been copied from the "Blast Furnace and Steel Plant" of June, 1918, gives a very clear comparison of these methods. The bending up method requires much less power than the counter flanges, and the wear on the rolls is less. On the other hand fewer passes can be laid out on a given roll length because of their increased width. This, however, is not so bad as may appear at first sight, because there is no need for enormously strong collars. A compromise is effected by the combination method.

We now come to the arrangement of the holes with regard to the rolling or pitch line. I regret that I have no time to discuss the interesting arguments of Schaefer and Tafel on this particular section of the roll turners' problem. Instructive as they are, they are put quite in the shade by Puppe's article in Stahl and Eisen (27th October, 1909) from which the following is condensed. To avoid confusion a few definitions are necessary.

The "pitch line" is a line parallel to, and half way between, the axis of the top and bottom rolls.

The "rolling line" is a base line parallel to, and immediately above or below the pitch line. It forms the basis on which to arrange the holes.

If the rolling line is below the pitch line the distance between them is called the "Overdraught," and the top roll is, therefore, larger than the bottom one.

If the rolling is above the pitch line, this distance is called underdraught and the bottom roll is the larger. As I have already mentioned, cogging rolls often come under this class.

It is the custom, in this country at any rate, to use overdraught for almost all sections. The idea is to prevent any chance of the bar lifting into the air, and to force it definitely against the lower guides, which can be more firmly fixed than the top ones. This object is very desirable, but there are other factors to be taken into account in attaining it. We have to consider the position of the center of gravity of the section as well as what I may term the "center of grip."

For thin flats where there is very little friction between the sides of the flat and the roll collar extremely little "overdraught" is sufficient.

Fig. 17 shows the effect of ¼-in. overdraught on a ½-in. flat rolled in a 36-in. mill. The flat tends to curve, as shown by the dotted line (which is drawn to scale). The end of the flat is caught on the stripper and slides forward setting up a bending moment which tends to straighten it. As the end advances, this bending moment increases until it exceeds the resistance of the flat. When this point is reached the flat gives way until a fresh contact is made with the stripper. This process repeats itself, and the result is a wavy bar.

The question of over or underdraught for channels and joists is not so simple. In these it often takes a very considerable force to release the flanges from their holes, and this must be allowed for.

The first two figures show a joist and a channel which will obviously tend to stick to the bottom roll. If the usual overdraught were given, this tendency would be increased and the result would be an enormous pressure on the stripper. To counteract this effect the bottom roll draught can be given without fear of the bar coming upwards. Similar reasoning also applies to T bars.

The use of under or overdraught in rolling flanged sections sometimes has a peculiar effect on the mill. The larger roll has a tendency to give the smaller one a higher speed of revolution. If the friction between the bar and the rolls is sufficient, the larger roll will drive the smaller. When the bar leaves the mill, the smaller roll will stop until the backlash in its couplings is taken up and its spindle can resume its drive. This causes the heavy knock which is sometimes heard just as the bar leaves the rolls.

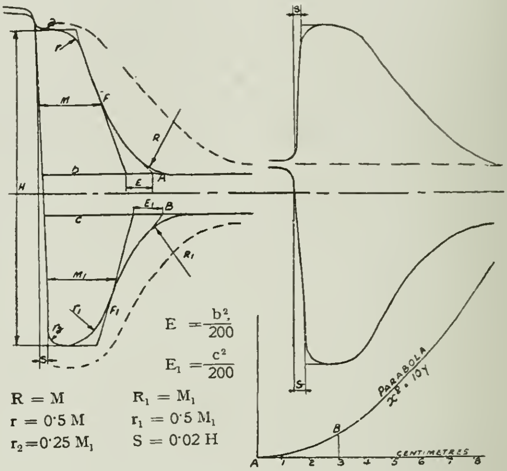


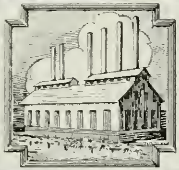
Fig. 15—Fillets and tapers for joint passes (Kirchberg).

The foregoing is very far from an exhaustive treatment of the subject. It is only a summary of the information I have collected from various sources. My object in presenting it has already been stated at the beginning. In closing, I have just one suggestion to make, and that is that practical roll turners should combine with theoretical men in order to obtain the best possible results, or better still, the practical man should be fully instructed in the theories governing this work. It is said that an ounce of practice is worth a pound of theory, but I think that the two combined together are worth a ton of either.

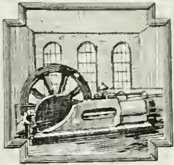
WILL BUILD NEW BLAST FURNACE.

Investigations which tend to show that iron ore exists in commercial quantities in this State are the background for the building of a blast furnace and steel plant at Tekoa, Wash., in the eastern part of the State, according to W. C. Hayward, president of the Commerce Steel Corporation, who declares that iron ores in the vicinity of Tekoa are equal to the Lake Superior ores. Mr. Hayward explains that only hematite ores so far have been found in this territory. He announces that his corporation will start construction immediately on a 75-ton capacity furnace.

Announcement here by transcontinental traffic officials of a proposed reduction of export steel rates contingent upon the assent of Eastern originating and intermediary carriers is expected, if ratified, to increase steel exports from the Pittsburgh and Colorado districts to the Orient through the Port of Puget Sound.



STEAM POWER DEPARTMENT



The Use of Medium Grade Gases in the Steel Industry

The Author Shows That Natural Gas, Even With Its High Heating Value, Is Not the Best Available Gas to Use in Steel Plant Heating.

By F. J. DENK

THE fuel gases principally used in the steel industry have been, up to the present time, either high grade gases, like natural gas, or low grade gases, like producer gas or blast furnace gas. Of the medium grade gases only coke oven gas has been used here and there and not as extensively as it should have been used.

It is the general belief, that natural gas, on account of its high heating value, is the best gas available. This belief, however, is erroneous. The efficiency of a gas does not depend upon its heating value, but it depends upon the flame temperature, the amount of air required for combustion, the specific heat of the waste gases and their quantity. These are the reasons, that the medium grade gases, i. e., gases with a lower heating value between about 350 and 500 Btu/cu. ft. are more efficient in a furnace, than the natural gas with a heating value of around 1,000 Btu/cu. ft. The accompanying table gives the heating values and the corresponding theoretical flame temperatures for the different gases in question.

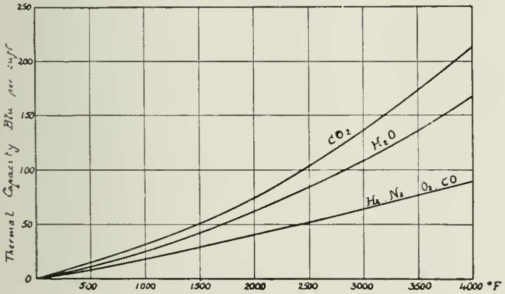


Fig. 1.

Gas.	Lower Heating Value.	Air Required.	Theoretical Flame Temperature.
Natural Gas	1018 Btu/cu.ft.	10.64 cu.ft.	3226 deg. F.
Carbon Water Gas	533 "	4.89 "	3422 deg. F.
Coke Oven Gas	425 "	4.06 "	3302 deg. F.
Elliott Gas	382 "	3.39 "	3400 deg. F.
Producer Gas	130 "	1.10 "	2673 deg. F.
Blast Furnace Gas	93 "	.70 "	2323 deg. F.

All gases to be considered cold and burned with the theoretically required minimum amount of air.

The table shows, that the quantity of air increases with the heating value. The higher the latter, the more air is required. But the increase in heating value is due to the increase in hydrocarbons. These hydrocarbons burn to carbon dioxide and water vapor, which are those two constituents of the waste gases, which have the highest specific heats. Besides, these specific heats increase rapidly with increasing temperature, whereas the specific heats for nitrogen, oxygen and air increase slowly. (See Fig. 1.) Water vapor and carbon dioxide absorb, therefore, under otherwise equal conditions, much larger quantities of heat, than nitrogen and oxygen or air and this is the reason for the

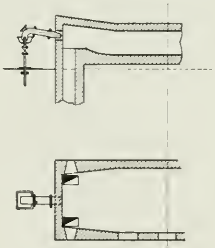


Fig. 2—30-ton O. H. furnace changed for medium grade gas.

lower flame temperature of those gases, which, like natural gas, are composed almost entirely of hydrocarbons, because they form, when burning, carbon dioxide and water vapor.

Elliott gas is a combination coal and water gas and may, for this reason, be named "Duo" gas. The main advantage in its manufacture is to be seen in the fact, that the volatile matter and the tarry vapors, driven off of the green coal right after charging, is burned into fixed gases, thus avoiding the necessity of adding oil to enrich the gas. So far it has been used and proven its value in the glass industry, but steps have been taken, to introduce it in the steel industry, where it will be found to be as efficient as coke oven gas.

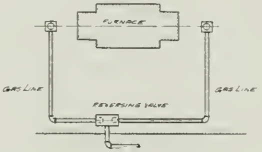


Fig. 3—General arrangement of gas piping to 30-ton O. H. furnace.

Actual tests have shown that the amount of gas made from one short ton of coal varied between 57,000 and 63,000 cu. ft. with a corresponding high heating value of 465 and 415 Btu/cu. ft. This gas takes, therefore, the place of coke oven gas, where there is not enough of the latter to supply all the needs of the steel plant, or where there is no coke oven plant at all. The maximum amount of gas obtainable from a coke oven plant is around 10,000 cu. ft., 1 ton of coal with about the same high heating value as Elliott gas.

This quantity, however, is obtainable only in a plant, where the heating of the ovens is done by means of producer gas or blast furnace gas. Wherever coke oven gas is used for this purpose, the above given amount will be reduced to about 6,000 cu. ft. per ton of coal. Now, there is no doubt, that it is of advantage for a blast furnace plant, to make its own coke, which will be cheaper than buying it outside, because the resulting gas can be charged to the steel plant. But 6,000 cu. ft. or even 10,000 cu. ft. per ton do not go very far and the conditions may become such, that the coke oven plant furnishes enough coke for the blast furnaces, but not enough gas for the steel plant. In this case an installation of Elliott producers will fill the needed want to perfection, because it furnishes a gas of more equal quality than coke oven gas, but it takes less space than a coke oven plant.

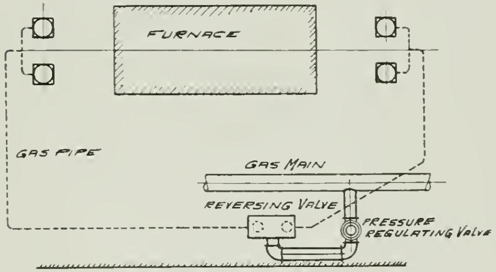


Fig. 4—General arrangement of piping for 100-ton O. H. furnace.

In the following some data will be given, showing the saving made when using coke oven gas over producer gas and a few sketches will illustrate the arrangement required for the use of coke oven gas on O. H. furnaces. Everything that is said below in connection with coke oven gas holds, for the reasons given above, also good for Elliott gas, the latter having the same heating value and the same specific weight.

Comparative tests on open hearth furnaces, fired with producer gas with 143 Btu/cu. ft. and with a coke oven gas having 408 Btu/cu. ft. showed the following results: With producer gas one long ton of steel required 661.5 lbs. of coal, whereas 11.477 cu. ft. of coke oven gas produced the same result. Assuming a producer efficiency of 89 per cent, the heat equivalent of the two fuels for one long ton of steel was 1414 Btu in the form of producer gas against 1,000 Btu in the form of coke oven gas. Besides, with the coke oven gas the daily output was 49 tons, with the producer gas only 39 tons.

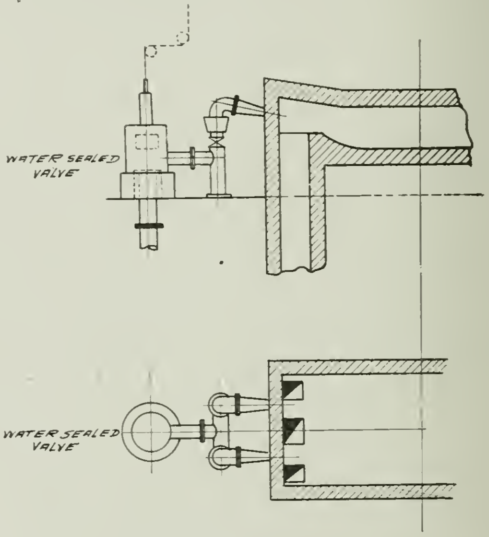


Fig. 5—Improved piping for 100-ton O. H. furnace.

In a 30 T open hearth furnace run with producer gas, the average length of the journey was 2½ months, giving 8,016 long tons of steel. The same furnace, run with coke oven gas had an average life of 3½ months, giving 10,725 long tons of steel. The coke oven gas fired furnace gave, therefore, 100 heats—2,700 tons more than the producer gas fired furnace.

In a 100 T open hearth furnace, the tonnage obtained in a charge was 96.5 tons, when fired with producer gas, against 97.3 tons when fired with coke oven gas.

In a 12 T open hearth furnace the daily production was 48 tons when running on coke oven gas against 39 tons, when running on producer gas, which is an increase of 23 per cent in favor of the coke oven gas. The average consumption of the latter was 9,888 cu. ft. long ton.

The main advantages in the application of coke oven gas or its equivalent may be found in the following.

1. Increase in production.
2. Simplification in the construction of the furnace, because the gas regenerating chambers can be omitted, the gas entering the furnace by means of ordinary burners.
3. Decrease in the cost for repairs.
4. Lower first cost and operating cost.
5. Easy working of the charge.

A formula for calculating the relative value of the different gases has been given by E. H. Steck.* It reads:

$$V_t = V_g \frac{T_t - T_r}{T_g - T_r} \times \frac{C_t}{C_g},$$

where

V_t the relative value of the new gas (coke oven or Elliott gas).
V_g the relative value of producer gas.
T_r the temperature in the furnace.
T_t the flame temperature of the new gas.
T_g the flame temperature of the producer gas.
C_t the Btu per cu. ft. of waste gases of the new gas.
C_g the Btu per cu. ft. of waste gases of the producer gas.

For instance, when a comparison is wanted of the relative value of using cold coke oven gas and cold air, against producer gas and air preheated to 1,000 deg. F., we have the following, when $T_r = 2{,}800$, $T_t = 3{,}300$, $T_g = 3{,}000$, $C_t = 106$ and $C_g = 143$.

$$V_t = V_g \frac{3{,}300 - 2{,}800}{3{,}000 - 2{,}800} \times \frac{106}{143} = 1.85\ V_g$$

for Elliott gas with $T_t = 3{,}400$ deg. F. we have

$$V_t = 2.21\ V_g.$$

This shows, that as long as the cost of coke oven gas is less than 1.85 times, and that of Elliott gas less than 2.21 times as high as that of producer gas, the two gases work more economical than the latter.

The use of the medium grade gases is not restricted to open hearth furnaces. They may be used in heating furnaces, mixers, sheet and pair furnaces, annealing furnaces, galvanizing pots, etc. In fact, for the last three types, Elliott gas is the most ideal fuel—coke oven gas being out of the question for obvious reasons—giving a clean gas of uniform composition, temperature and pressure.

Fig. 2 shows section and plan of a 30 T open hearth furnace; Fig. 3 illustrates the arrangement of the gas pipes, burners and the reversing valve for the same furnace. Fig. 4 shows the gas piping, burners and reversing valve for a 100 T open hearth furnace.

With this arrangement explosions frequently occurred in the lines on the waste gas side, due to the remaining of some unburned gas in these lines, which formed explosive mixtures with the furnace atmosphere. The same happened when during shut-downs gas entered through leaking valves. This trouble was prevented by installing another water-sealed valve on each head of the furnace close to the burners as illustrated in Fig. 5.

It is needless to say, that every furnace, which has been operated with a low grade or a high grade gas, must be changed to suit conditions, when it is to be operated with a medium grade gas. This is a point, which is often overlooked. When, then, the furnace is not working properly and does not give the expected results, the blame is invariably laid to the new fuel but not, where it should be laid, i. e., to the furnace.

MECHANICAL ENGINEERS MEET.

Announcing that a 5-day annual meeting will be held in New York, December 5 to 9, the American Society of Mechanical Engineers has made public a statement by Herbert Hoover saying that the investigation of industrial waste recently completed by the American Engineering Council of the Federated American Engineering Societies has paved the way for an advance in American industry. The findings of this council's Committee on Elimination of Waste in Industry will form the leading topic of discussion.

Conditions in five basic industries "assayed"—to use Mr. Hoover's description—by the committee will be discussed December 5. The industries include the metal trades, printing, boots and shoes, clothing and building. In the evening will come a session on education and training in the industries.

On December 6 simultaneous sessions on railroads, power, and machine shop practice will be held. Speakers at the machine shop session will include Prof. John Airey, University of Michigan, who will discuss "The Art of Milling," and J. A. Smith, General Electric Co., and J. J. Callahan, Worcester, Mass., who will speak on "Waste in Machine Industry."

Sessions of the fuel and material handling divisions and of the student branches of the society will be held December 8. In the afternoon a joint session with the Society for the Promotion of Engineering Education will be held, on "Professional Engineering Education for the Industries." Speakers will be F. C. Pratt, vice-president General Electric Co. and president Yale Engineering Society; J. E. Otterson, president Winchester Repeating Arms Co., New Haven; Dexter S. Kimball, president-elect of the society, vice-president American Engineering Council and dean of engineering at Cornell; and Prof. A. G. Christie, Johns Hopkins. On December 9 sessions of the textile, ordnance and aeronautic sections will be held. The ordnance sessions will take up the recent army demonstrations at Aberdeen, Md., where the mechanical engineers cooperated.

NEW YORK ELECTRO CHEMISTS HOLD A MEETING IN MEMORY OF DR. J. W. RICHARDS.

A meeting of the New York section of the American Electrochemical Society was held Wednesday evening, November 16, at Rumford Hall, 52 East Forty-first Street, New York, at which several addresses were delivered on the life and works of the late Dr. Joseph W. Richards. Dr. Carl Hering, consulting electrical engineer, Philadelphia, reviewed the work of Doctor Richards as president and secretary of the American Electrochemical Society; Dr. W. S. Landis, president American Cyanamid Co., New York, took as his theme, "Dr. Richards as a Teacher at Lehigh University," while H. C. Parmele, editor "Chemical and Metallurgical Engineering," reviewed Doctor Richards' work as an editor and author. These memorial addresses were followed by one by Dr. Frederick G. Cottrell on "Personal Observations on the Russian Situation."

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*The application of blast furnace gas and coke oven gas in the steel industry. Fenerungstecknik, Vol. 11, Number 5.

Successful Ash Conveying System

New Plant as Installed at the Works of the Sweet Steel Company of Williamsport, Pa., Is Giving Very Good Success—Useful to Plants Having Boilers or Gas Producers

By CHARLES LONGENECKER

THE economical disposition of ashes from gas producers or boiler furnaces is, at many plants, a serious problem. Some plants are so fortunately located that the problem is readily solved, but this is not the case with the majority. In most cases there are limitations imposed which in themselves determine the type of equipment permissible, while again the cost of equipment may preclude certain systems. The latter is very frequently the controlling feature. To those engineers confronted with such limitations as those mentioned, a description of the ash conveying system installed at the plant of the Sweet Steel Company at Williamsport, Pa., may be of interest. The simplicity of the device as a unit and its low first cost will appeal to those who are limited in space for such an installation as well as limited in means for the purchase of additional equipment.

The system referred to is illustrated in Fig. 1 as applied to gas producers and boilers. For the sake of illustration the general scheme as applied to boilers is to be preferred. The motive power is steam, which forms a suction of air from the air inlet to the steam jet and from the jet propels of its own force. In this illustration the opening into the conveyor pipe is seen in close proximity to the producer or furnace. The details of this opening can be better understood by reference to the small insert and marked as detail "A." At the entrance there is a plate termed the anvil plate upon which are placed any clinkers which are too large to drop into the pipe. When a clinker is placed on this plate and struck a sharp blow it is broken into pieces which, dropping into the pipe, are at once carried away. At the point "D" in the general layout is the 90-degree steam unit. This is one of the most important features of the whole system and on it depends the success of the installation, both physically and economically.

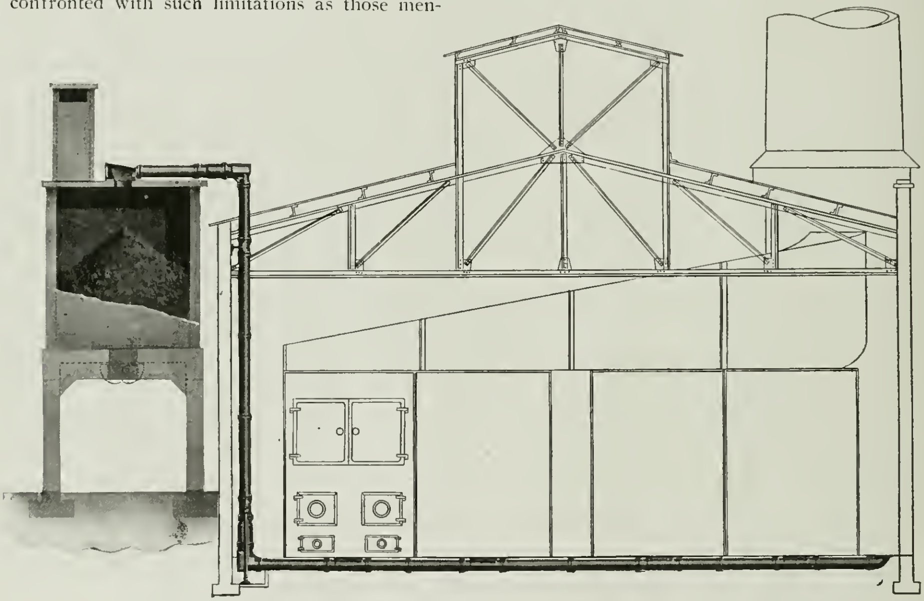


Fig. 1.

The vital points in connection with this 90-degree steam unit are the location of the steam nozzle and the construction of same. The axis of this nozzle must be in perfect alignment with the axis of the pipe into which the steam is blown. Should the alignment be otherwise than perfect the wear on the pipe lining will be too severe and costly erosion be the result. This alignment is assured by means of an accurately tapped gray iron insert into which the nozzle bushing screws. In the early conveyors the steam nozzles were made of bronze, but after some time it was found that these would not preserve their original form, but that the steam would cut out the metal with the result that more steam was consumed than was necessary for the work. Many experiments were tried to remedy this defect until finally monel metal was found to possess the qualities desired and nozzles cast of this metal have given the best of satisfaction. The nozzle is so constructed that it can easily be removed and another inserted with only a few minutes delay.

Next to importance to the steam nozzle in construction is the pipe through which the ash passes. The abrasiveness of ash is known to all, but some ash possesses this quality to a greater degree than others. Naturally, the rapid passage of this material through the pipe causes a certain cutting of those parts in contact with the ash, but at certain points this cutting action is more severe than at others. The point of wear is found where the pipe makes the 90-degree turn and just above the steam nozzle. The construction of the pipe at this point and at all other bends is ingenious.

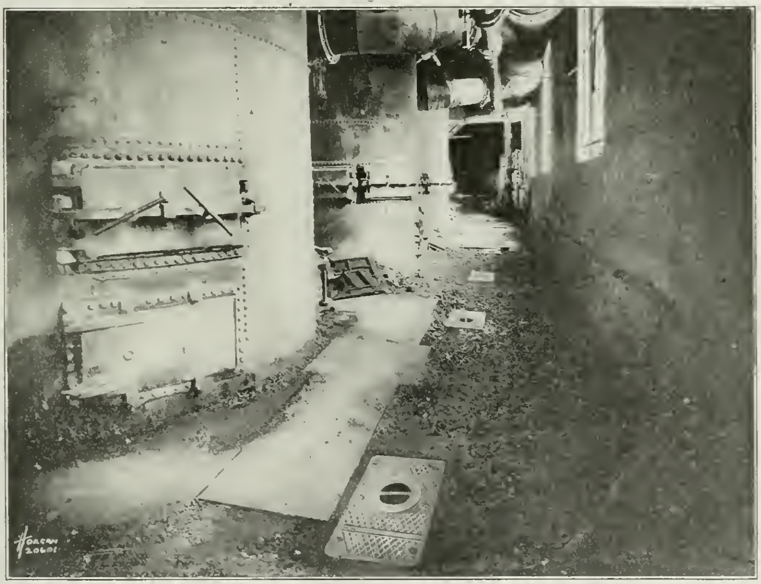


Fig. 2—Plant installed at the Hyde Park Gas Company, Scranton, Pa.

In the illustration will be noticed the additional lining which is made in small sections about 7 inches long and cast from a special brake shoe insert metal which is exceedingly hard. This lining extends about four feet above the nozzle and is rapidly interchangeable. The doors giving access to the lining are secured by steel spring bars and are in no case bolted. It has been found that bolts have a tendency to rust and when rusted are difficult to remove. Where the spring bars are used it requires only the tap of a hammer and the door opens. These liners will not need replacing until some 5,000 tons of ash have passed over them and are furnished at all bends in the line from 45 degrees to 135 degrees.

In case of heavy tonnage protection is also afforded the bottom of the suction line as here there is a certain amount of erosion. The liners extending along the bottom are cast in sections varying from 18 in. to 24 in. —thus it is a very simple matter to renew these through the intake openings.

The pipe itself is about 1 in. in thickness, 8 in. inside diameter and will weigh approximately 100 pounds per linear foot. This pipe is not machineable, as it is composed of a special iron known as "carbo-iron," which is a white iron of extreme hardness.

One other point presented an opportunity for ingenious construction. This is the last section of the pipe where the ash is discharged from the system. The difficulty which arose here was that the ash leaving the pipe at a high velocity cut into any obstacle which was installed to take the impact. The solution was the building of a special casting known as the "ash cushioning deflector box." This is seen in the illustration at the discharge end and is marked "B." The casting is so formed that a cushion of ash collects in a space which forms a pocket. The ash leaving the pipes strikes this cushion and drops into the receptacle provided for its collection. Where it is possible to discharge the ash into any open outdoor space to be filled there is no necessity for this ash deflector. This is the case at one steel plant where the ashes are used to fill a swamp depression. Here the length of the line from the boiler room to the disposal point is 195 feet.

In operation this method of ash disposal will consume approximately 350 pounds of steam per ton of ash removed. This quantity will vary with the steam pressure and with the length of the line. The capacity of the installation at the plant in question is from six to eight tons of ash per hour. The ash is removed at such a time as is most convenient with regard to the operation of the steel plant. Usually it is most desirable to discharge the ash at noon when the demand for steam is not so pressing and when in many in-

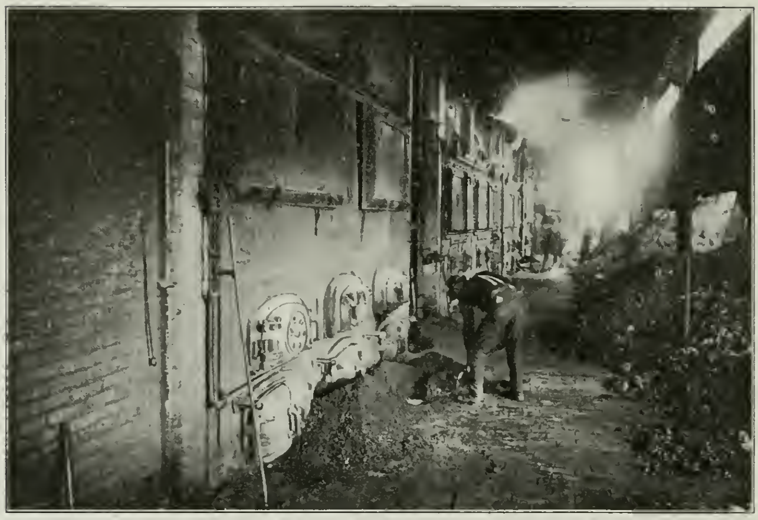


Fig. 3--Plant Installed in Sweet Steel Company, Williamsport, Pa.

stances the steam can be used with practically no cost. Instead of letting the steam blow off into the air, which it will do when there is no demand, it is employed for the more useful purpose cited.

The maintenance cost will not exceed 2½ cents per ton of ash unless there is some unusual condition, but the condition must be most unusual to be higher than this figure.

Besides the savings in operation which will accrue, there is the elimination of dust which is the case where ash is handled by hand or in machinery which agitates it. The labor question is at once solved as there is no extra labor required.

The system here described was installed by the Girtanner Engineering Corporation of New York. This company has standardized the parts entering into the construction and this has further simplified the complete installation.

METAL COATINGS FOR IRON.

A series of tests on the durability of metallic coatings, applied to iron to prevent rusting, were conducted by Dr. W. Lange, of Berlin, on behalf of the War Office during the war, and the results of the tests were published in the April and June issues of the "Zeitschrift fur Metallkunde." The protective metals tested were zinc, lead, tin, aluminum, and the tests were made on foils or wires, in water (distilled or tap water), in diluted solutions of common salt or sea water, and in the open air, sometimes saturated with moisture and carbon dioxide. In the case of zinc various electrolytic baths were used, and also the nigrosin treatment of Langbein-Pfanhauser, in which a film of black nickel is finally deposited by electrolysis on the coating which is subsequently greased with vaseline; the good results obtained may partly be due to the vaseline. Electrolytic zinc coatings failed in many cases because they were of insufficient thickness. Dipping into fused zinc avoids this trouble; sherardizing answered nearly as well as this last process, although the coatings were not of uniform thickness; spraying after Schoop was also fairly satisfactory, except in distilled water—which is far more destructive to all zinc coatings than tap water—and in salt solution. Of the electrolytic lead baths those of Betts (hydro silico-fluoric acid) and of Schlotter (phenolsulphonic acid) answered best; distilled water again proved more destructive than tap water and salt solution. When lead is to be sprayed on, a film of zinc or tin should first be applied to the iron by spraying in order to secure adhesion. In the case of tin, alkaline baths, a solution of the double tin ammonium chloride and the Schlotter acid were tried; the last-mentioned bath answered best. A steel tube dipped into molten tin, rusted in three weeks when heated by steam during the day and kept cold at night. Very good results were obtained with aluminum-spraying. Some new secret processes did not pass the tests at all satisfactorily.

ALLOY WORK DISCUSSED.

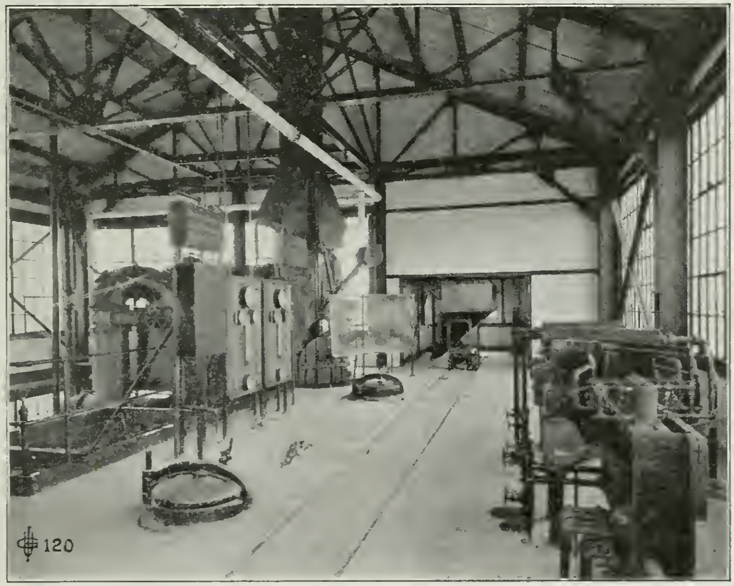
The work on alloys being done by the Bureau of Mines was reviewed at a meeting between bureau officials and the standing committee of the American Institute of Metals. It was decided that the standing committee would meet twice a year in the future at the Bureau of Mines. Those in attendance at the meeting were: H. Foster Bain, director, Bureau of Mines; W. M. Corse, Monel Metal Products Corp.; R. B. Moore, chief chemist, Bureau of Mines; William B. Price, Scovill Manufacturing Co.; W. H. Bassett, American Brass Co.; R. J. Anderson, Bureau of Mines; L. W. Olson, Ohio Brass Co.; C. H. Bierbaum, Lumen Bearing Co.; George C. Stone, New Jersey Zinc Co.; W. R. Webster, Bridgeport Brass Co.; H. W. Gillett, Bureau of Mines; DeCourcy Browne; Paul D. Merica, International Nickel Co.; J. L. Jones, Westinghouse Electric & Manufacturing Co.; John F. Thompson, International Nickel Co.; William A. Cowan, National Lead Co.; Andrew Stewart, Bureau of Mines; Dorsey A. Lyon, Bureau of Mines; E. L. Mack, Bureau of Mines.

"You have it when you need it."

BLUE GAS

Is Used Effectively In Substitution For

NATURAL GAS



The Operating Floor of a 3,200,000 cu. ft. per Day Plant is Shown Above

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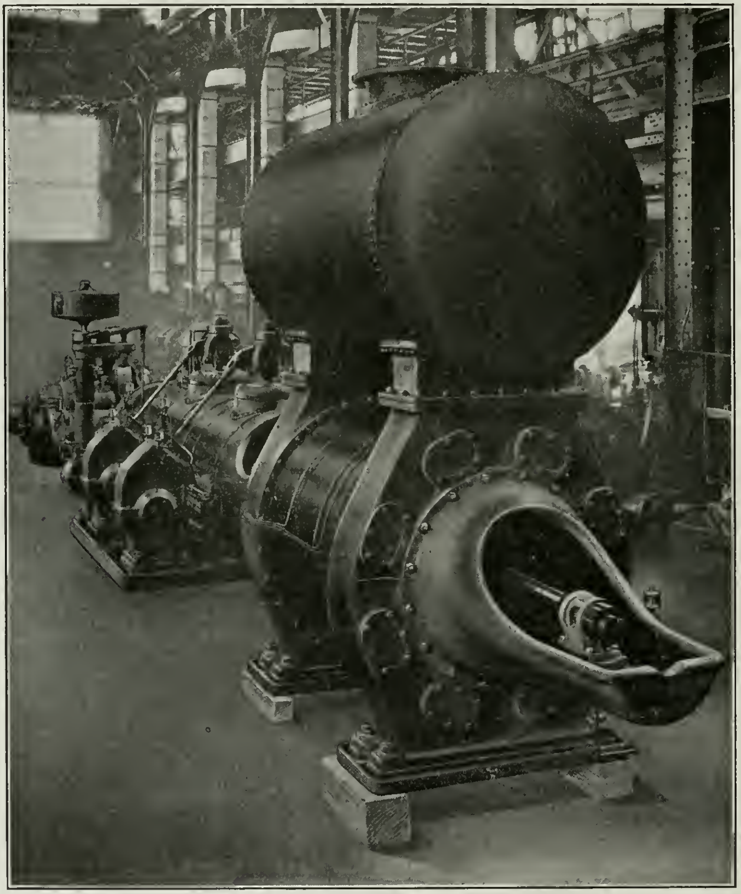
MESTA
UNA-FLOW TYPE BLOWING ENGINES
(BUILT UNDER STUMPF PATENTS)



Mesta Una-Flow Type Blowing Engine on Erecting Floor.

PRESENTING THE LATEST FEATURES IN BLOWING ENGINE CONSTRUCTION

Simpler in construction and yet more economical in steam consumption than any other type of steam blowing engine.
Especially adapted for high steam pressures and superheat.
Air cylinders equipped with Mesta automatic plate valves (Iversen Patent).
Built in single cylinder or twin cylinder units.

Write for Bulletin "U"

MESTA MACHINE COMPANY
PITTSBURGH PENNSYLVANIA

WITH THE EQUIPMENT MANUFACTURERS

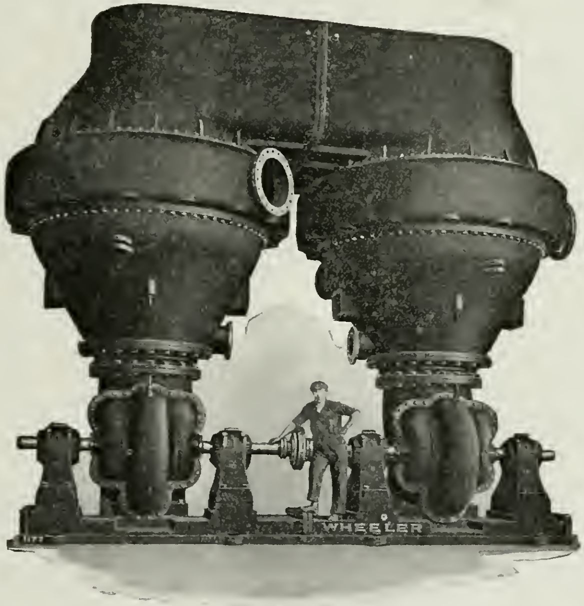
A TWIN-JET CONDENSER FOR 20,000-KW TURBINE

Herewith is illustrated the latest large jet condenser unit manufactured by the Wheeler Condenser & Engineering Company, Carteret, N. J., which is of special interest on account of its size and the operation of auxiliaries. It was built to serve a 20,000-kw General Electric turbine at Hauto, Pa., plant of the Pennsylvania Power & Light Company. Designed for 28-in. vacuum with 75-deg. injection water, it will handle a total of 25,000 gpm, or 12,500 gpm for each removal pump.

Twin jet condensers are frequently furnished for serving large units because they have greater flexibility, are easier to handle, and reduce the headroom. Each condenser body, as shown, is mounted over a separate removal pump, and will also be provided with separate air pumps, so in times of light load or with cold injection water, only one-half of the unit need be operated, resulting in a saving of 50 per cent of the normal power. When in full operation, the water levels in the two bodies are equalized by means of a connecting pipe, flanges for which are the two lower ones shown on the condenser bodies opposite each other.

Both a geared turbine and motor are furnished to drive the removal pumps of this unit—each being large enough to drive both pumps alone—so that the load can be divided as required to maintain the heat balance of the plant by producing more or less exhaust steam, as can be utilized economically for heating feed water. These are not shown in the photograph, as they were sent direct to the plant and could not be assembled in the shop where the photograph was taken. A feature of the pump drive is a magnetic clutch, which unites the shafts between the inside shaft bearings. It permits either pump to be driven independently of the other, without interfering with continuous operation, when only one half of the condenser is to be operated.

As will be noted from the photograph, an expansion joint is provided between each condenser body and its removal pump. By this arrangement, the condenser body is suspended from the turbine nozzle, while the removal pump and its driver are mounted upon a rigid foundation, the expansion joint absorbing temperature strains. An expansion joint provided in this way eliminates the large expansion joints usually placed between the turbine and the condenser.



Large jet condenser for 20,000-kw turbine.

Another point of interest is the vertically split casing of the horizontal double suction tail water pump serving each condenser. When it is necessary to inspect or repair the rotor or any of the wearing parts, it is simply a matter of removing the bolts, and uncoupling the rotor. Before this design was developed, considerable time and effort were required to get at and remove the rotor.

This huge condensing unit will be served by two large Wheeler steam jet air pumps of the combined surface intercondenser and heater type, and two turbo air pumps, each pump being large enough for one condenser. Boiler feed make-up is circulater to the intercondenser and heater of each steam jet air pump.

STEEL PICKLING COMPOUND

The Hoffman Process Company of Pittsburgh, Pa., has developed an organic compound to improve the practice of pickling steel, iron and copper.

This compound is perfectly soluble and is used in what might be called a trace, since one pint at two hour intervals suffices for a tank containing 1,000 to 1,500 of pickling solution.

It has two effects, the first, through an increase of surface tension, is to produce a foam which acts as a filter, preventing the escape of noxious acid vapors, which damage buildings, machinery and injure the health of workmen.

The second effect is described by the U. S. Bureau of Mines as inhibitive and is regarded as the most important, although less noticeable.

The solution is no longer one of acid and water, but one of acid and water plus an organic compound whose action is quite different since it reduces the action of the acid on the metal and directs it to the solution of scale. The result is a saving of 15 to 20 per cent of the acid usually required to clean the metal; a saving of the metal which would be otherwise destroyed by this excess of acid and a smoother surface which, if galvanized, requires less spelter to coat.

As an example, an extended test in a wire mill using 30 tons of 66-deg. sulphuric acid showed a saving of five tons of acid daily and two and one-half tons of metal through the use of five gallons of this compound. Another customer reported a saving of 22 per cent of his acid and a reduction of his galvanizing cost of 15 per cent.

NEWS OF THE PLANTS

The Hancock Steel Company, Martinsburg, W. Va., has completed plans and will call for bids at an early date for the construction of its proposed new plant at Brosius, W. Va., near Hancock, Md.; with initial main building to be one-story 130x200 feet. A number of other buildings will also be erected. The new plant is estimated to cost in excess of $500,000. The company has recently increased its capital to $3,000,000, to carry out the details of the project. F. Vernon Aler, Martinsburg, heads the organization. Ernest McGeorge, 1900 Euclid Building, Cleveland, Ohio, is engineer.

The Bethlehem Steel Company, Bethlehem, Pa., has recently resumed operations at its Furnace D, making two units now in blast at the plant. The furnace was banked last April. Blast Furnace G at mill is being relined. At its Steelton, Pa., works, the company has resumed production at the 24-in. rolling mill, which has been idle for some weeks past.

The New England Steel Castings Company, East Longmeadow, Mass., has called for bids for the rebuilding of its local plant, recently destroyed by fire, with loss aggregating close to $75,000. The new structure will be one-story, 68x122 feet, brick and steel. Morris W. Maloney, 145 Chestnut Street, Springfield, Mass., is architect for the work.

In connection with its entry into the rail manufacturing industry, the Inland Steel Company, Block Avenue, Indiana Harbor, Ind., is planning for the conversion of its local structural steel mill into a plant for the manufacture of steel rails. It is proposed to install the necessary machinery to provide for an output of about 2,000 tons of material per day. Present schedule calls for operation early in March. The executive offices of the company are at 388 Dearborn Street, Chicago, Ill.

The American Steel & Wire Company, 94 Grove Street, Worcester, Mass., is pushing construction on the new plant addition to its South Works, and plans for early occupancy for general increase in production. It will be three-story, 120x145 feet, and is estimated to cost approximately $150,000. C. E. Goodrich is company engineer.

The Kansas City Spiral Pipe Company, 416 Dwight Building, Kansas City, Mo., has acquired property at Leeds, Mo., for the erection of a new plant for the manufacture of riveted steel pipe. Plans are under way for the initial works, to comprise a one-story brick and steel building, 60x300 feet. E. J. Gordon is secretary of the company.

The Rochester Rolling Mills, Rochester, N. Y., have been organized under state laws to operate a local iron and steel works. The company is headed by F. Christman, J. Noraconk and J. H. Farrell, Rochester. It is represented by F. I. Stoker, attorney, Rochester.

The McKinney Steel Company, Cleveland, Ohio, has plans nearing completion for a new sintering plant at its works to have a daily capacity of approximately 350 tons. It is proposed to inaugurate construction early in the coming year.

The Carnegie Steel Company, New Castle, Pa., has placed another furnace in blast at its local plant, increasing production to a point about 75 per cent of plant capacity.

The Chester Iron & Foundry Company, 7800 Vulcan Street, St. Louis, Mo., has completed plans for the erection of an addition to its plant for increased capacity, to be 45x115 feet, and estimated to cost about $42,000. L. Haeger, 3824 Utah Street, St. Louis, is architect. A. J. Schaelieh is president of the company in charge.

The Charleroi Iron Works, Charleroi, Pa., manufacturer of structural shapes and other iron and steel products, has removed its works from the buildings on McKean Avenue, heretofore occupied, to a new site in the lower section of the city. The new buildings will provide for increased production.

The Agricola Pipe Company, Gadsden, Ala., manufacturer of iron pipe, is arranging for the rebuilding of the portion of its local plant recently destroyed by fire with loss estimated at $75,000, including machinery. Otto Agricola is president of the company.

S. Cheney & Sons, Seneca Street, Manlius, N. Y., manufacturer of iron products, have plans under way for the construction of a new building at their plant, for increased production; it will be one-story, brick. Melvin L. King, Snow Building, Syracuse, N. Y., is architect for the work.

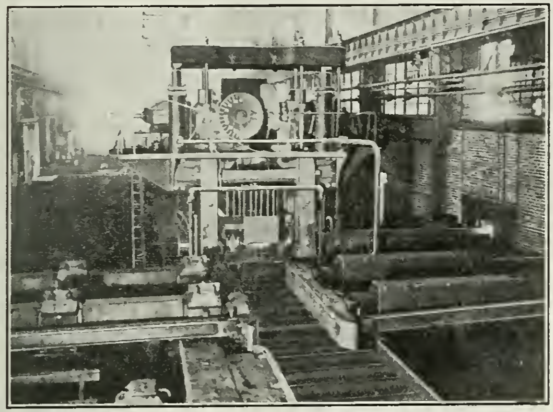
The O. J. Bloss Iron Works, 253 Monitor Street, Brooklyn, N. Y., will soon commence the erection of a new one-story plant building, to be about 30x100 feet. It will be located on Henry Street, near Norman Avenue. Charles A. P. Jehle, 350 Fulton Street, Brooklyn, is architect.

The Omaha Semi-Steel Foundry Company, 1409 Jackson Street, Omaha, Neb., operated by Bergman & Hinkens, has completed plans for the construction of a new one and two-story and part basement plant building at Eleventh and Grace Streets. It will be about 80x100 feet, and is reported to be estimated to cost close to $50,000. W. F. Gernandt, 701 O. L. & B. Association Building, Omaha, is architect.

Blast furnace operations are on the increases in the Buffalo, N. Y., district, and a number of stacks have recently been blown in. The iron and steel companies in this section are reported to be planning for early increase in present production. The Rogers, Brown Company has blown in a second furnace at its mill, and expects to keep the two units in blast. The Donner Steel Company has also placed a second stack in operation at its mill. The Lackawanna Steel Company has one blast furnace running at the present time for the production of pig iron for the general commercial market. The Buffalo-Union Furnace Company has one blast furnace in operation, as has also the Wickwire-Spencer Steel Company.

The Ellwood Ivins Tube Works, Oak Lane Station, Philadelphia, Pa., has construction well under way in connection with the rebuilding of its plant, destroyed by fire some time ago. The company specializes in the manufacture of seamless steel tubing, and four of the new buildings are now being occupied for general production. A number of other structures are nearing completion and will be placed in service at an early date. The complete plant is estimated to represent an investment in excess of $200,000. Ellwood Ivins heads the company.

Modernize Your Blooming Mill M-H Co. Patent Manipulator



(*Showing Manipalator ready for ingot*)

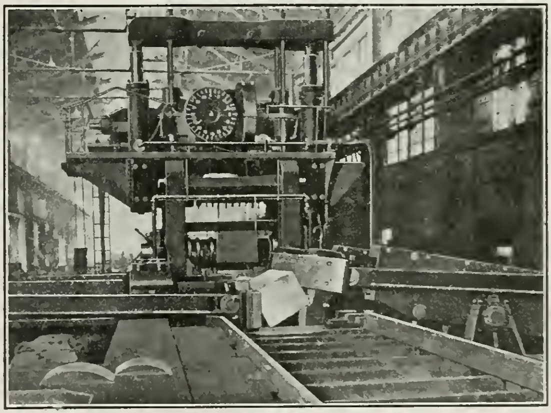
What it is--

The M-H. Co. Patent Manipulator ***combines*** a Side Guard and Finger Manipulator with ***no parts*** under table. It is entirely independent of tables, away from scale and accessible to cranes.

Operated Electrically or Hydraulically

What it does-

It fills a long felt want for a rapid and positive manipulator that saves ***time***—eliminates break-downs, increases tonnage and assures uniform product. It also reduces to a minimum the ***wear*** and ***tear*** of mill tables.

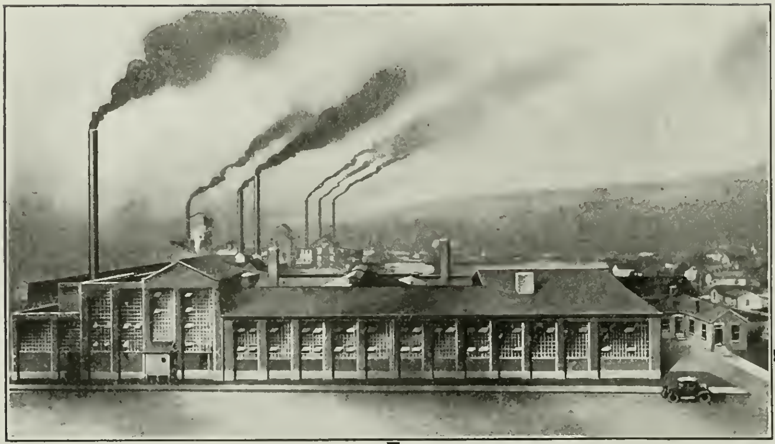


(*Showing turning of ingot by tilting unit*)

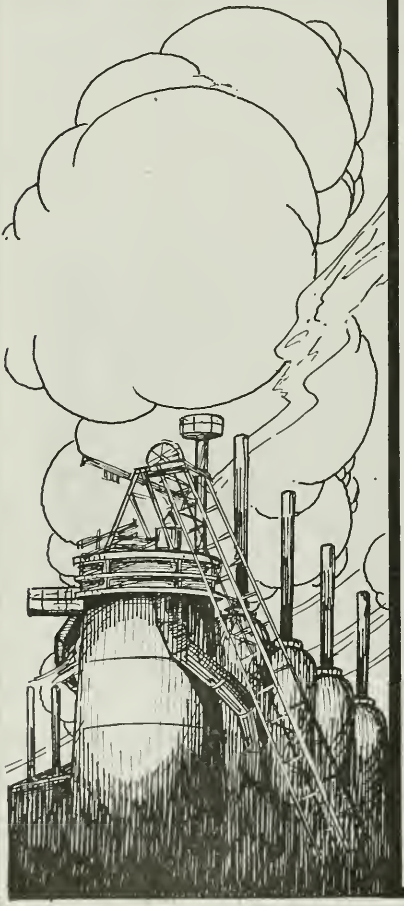
Pictures show installations at Lowellville plant, Sharon Steel Hoop Co.

Mackintosh-Hemphill Co.

Pittsburgh, Pa.



One of the plants of the Ashland Fire Brick Company, located at Ashland, Kentucky.



ASHLAND FIRE BRICK

The most important factor controlling the characteristics of a fire clay refractory is the raw clay used in its manufacture

The clay deposits owned by the Ashland Fire Brick Company are considered to be of unusual quality, three kinds of clay being available, plastic, flint and semi-flint.

Each of the three types has its particular good properties.

By using different proportions of the three clays mentioned and treating them in different manners, through the Special Ashland Process, it is possible to produce a fire brick having nearly any desired characteristic.

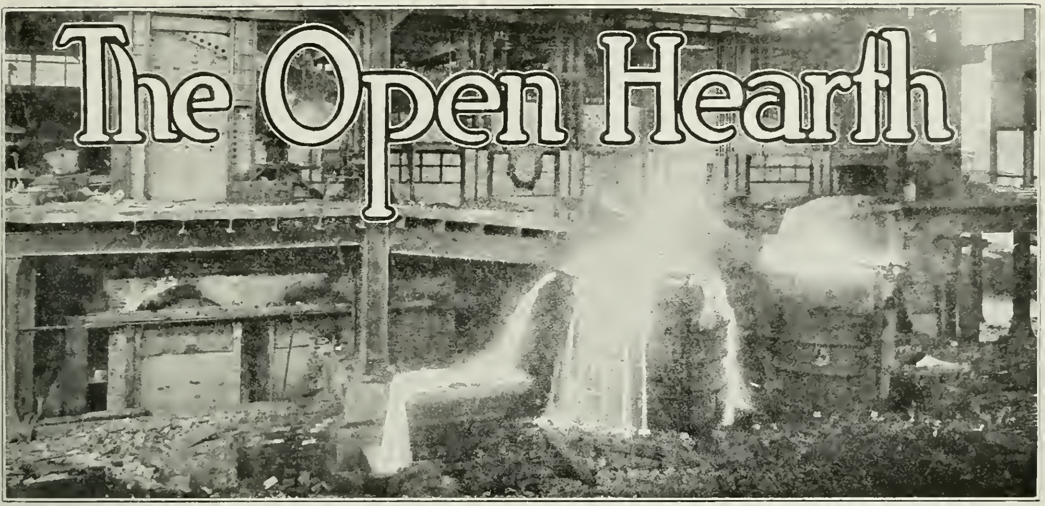
We are exceptionally well equipped to furnish special shapes and sizes.

"Line with the Ashland Line."

Ashland Fire Brick Company

Incorporated 1886

Ashland, Kentucky



The Open Hearth

T. G. Shelton of High Point, N. C., has been appointed general manager of the American Foundry Company, which recently was organized at Salisbury, N. C.

* * *

Victor E. Hillman, metallurgist at the Crompton & Knowles Loom Works, Worcester, Mass., is to be the instructor of a class for the elementary instruction in treatment, manufacture and fabrication of steel, to be formed by the Worcester, Mass., chapter, American Society for Steel Treating.

* * *

T. A. Jones has been elected president of the W. A. Jones Foundry & Machine Company, Chicago, Ill., to succeed William A. Jones, who died recently. Mr. T. A. Jones has been secretary and treasurer of the company for several years. W. G. Jones who has been manager, continued in that position and also has been elected vice president and treasurer. J. A. Sizer has been elected secretary. The former policy of the firm is to be carried forward without change.

* * *

C. H. Hobbs has been appointed assistant general manager of sales of the Detroit Seamless Steel Tubes Company, Detroit, a newly created position. Mr. Hobbs was formerly with the Lackawanna Steel Company with which Company he served for 14 years.

* * *

Edward E. Book has been appointed welfare director of the Youngstown Steel Car Company, Niles, Ohio. For several years he was in the employ of the Pittsburgh & Lake Erie Railroad at McKees Rocks, Pa.

* * *

Bradley Wheeler recently resigned his position as open hearth superintendent of the Minnesota Steel Company, Duluth.

* * *

William Weaver Lukens, who resigned recently as president of the Alan Wood Iron & Steel Company, Philadelphia, was presented with a silver loving cup by the employes of the main office of the company.

* * *

Charles H. Chubbuck, chief engineer for the McClintic-Marshall Co., Pittsburgh, recently returned from China where he was identified with bridge and other construction work.

Howell Macduff, son of Thomas Macduff, cashier of the Worcester, Mass., district of the American Steel & Wire Company, has taken a position on the superintendent's staff at the north works of the company in that city.

* * *

C. A. Dunn has resigned his position as general superintendent of the Detroit Seamless Steel Tubes Company, Detroit, to become connected with the sales department of the Prime Mfg. Company, Milwaukee.

* * *

Benjamin F. Jones, Jr., president of the Jones & Laughlin Steel Company, Pittsburgh, has donated $25,000 for building of a home for the new dean of the engineering school, Princeton University, Princeton, N. J.

* * *

Theodore Wagner, New Britain, Conn., who, for 37 years, was foreman of the Stanley Works and who resigned four years ago to accept a position with the Worcester Pressed Steel Co., Milford, Conn., was recently made general superintendent of John D. Crosby Co., Pawtuckett, R. I.

* * *

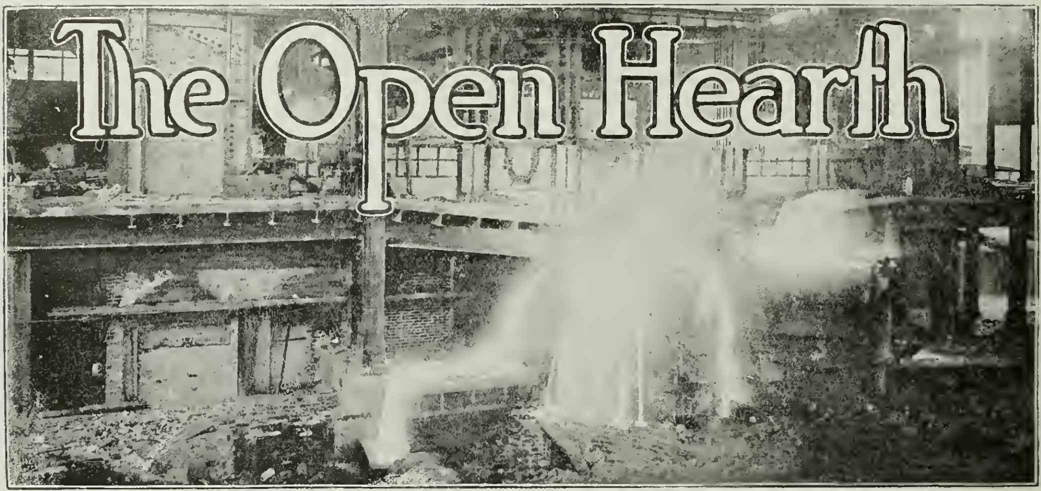
Harry Ross Jones, president of the United Alloy Steel Corporation, Canton, Ohio, and Edward L. Hang, vice president and secretary, have resigned effective December 31st, after 18 years continuous service in the organization. Both men will continue to serve on the board of directors and Mr. Jones will remain on the executive committee of the company until the annual meeting next April. Mr. Jones, it is announced, will look after his personal interests while Mr. Hang will go to the Southwest for a rest until spring.

* * *

A. Clarke Moore, formerly assistant to the president of Globe Seamless Tube Company, was recently appointed vice-president of the Chicago Railway Equipment Company, Chicago, succeeding the late C. Haines Williams, deceased. Mr. Moore will have general supervision of the manufacturing and selling departments.

* * *

A. L. Humphrey of Pittsburgh, president of the Westinghouse Air Brake Company, Wilmerding, Pa., and a director of the Chamber of Commerce of Pittsburgh, has been selected as one of 14 regional directors under the National Unemployment Conference's emergency relief program.



The Open Hearth

George K. Vail, general manager of Arthur G. McKee & Company, engineers, Cleveland, has been elected president of the Ohio Steel Foundry Company, Lima, Ohio, and will leave the McKee firm to become affiliated with the Lima company November 15. Previous to joining McKee & Company, Mr. Vail was associated for some time with the Westinghouse Electric & Mfg. Company, first as a salesman in its Cleveland office and later as district sales manager.

V V

A. D. Chisolm is in Brazil inspecting properties for the Steel & Tube Company of America, Chicago.

V V

G. Herbert Jones, vice president and one of the founders of the Inland Steel Company, Chicago, who, for the past 28 years, has been in active service in charge of sales, has asked to be relieved of his duties in order to rest and devote his time to other interests. Formal action has not been taken and his resignation has not been made formally. However, he is anxious to make the change and it may become effective with the end of this year. Mr. Jones has been an aggressive director of sales for Inland Steel Company in the years of its great growth from a small beginning and feels he has earned a rest. He is developing a fluorspar mine near Rosiview, Ill., the Hillside mine, which is being equipped with modern machinery and every device for the economical production of this material. Mr. Jones desires to devote more time to this interest. In his retirement as vice president he will retain his interest in the company and probably will continue as a director and member of the executive committee.

V V

J. J. Wilson has taken charge of the foundry division of Hiram Walker & Sons Metal Products, Ltd., Walkerville, Ont., a new company which will make a general line of motor castings. Mr. Wilson was formerly connected with the General Motors Corporation in charge of all its foundries.

V V

Col. Henry P. Bope has been elected president of the International Steel Tube Company, Cleveland. Col. Bope was recently director of this Company and R. A. Harmon has been made chairman of the board of directors. Col. Bope formerly was first vice president and general manager of sales of the Carnegie Steel Co., Pittsburgh.

Ralph D. Mock, vice president and former comptroller of the Hydraulic Steel Company, Cleveland, has been made vice president associated with sales; Harry W. Kranz, former superintendent of the Cleveland Welding & Mfg. Company, a subsidiary of the Hydraulic Steel Company, has been made manager of the welding plant and Charles S. Holden, formerly in the sales department of the Cleveland Welding & Mfg. Company, has been made sales manager of the welding plant.

V V

Percival S. Andrews was recently promoted from head bookkeeper to assistant superintendent of the Spencer, Mass., works of the Wickwire Spencer Steel Corporation, Worcester, Mass., and Buffalo.

V V

John V. W. Reynders has been elected chairman of the iron and steel committee of the American Institute of Mining and Metallurgical Engineers, succeeding the late Prof. Joseph W. Richards of Lehigh University.

V V

Walter C. Carroll, assistant general manager of Sales of the American Sheet & Tin Plate Company, Pittsburgh, for the past 13 years, has resigned his connection in this capacity to become vice president and general manager of sheet sales of the Inland Steel Company, Chicago. Mr. Carroll takes with him to his new position a very complete knowledge of the steel business, particularly of steel sheets, acquired over the 13 years he has been affiliated with the American Sheet & Tin Plate Company.

V V

Francis Samuelson, who, it was announced at the Paris Steel Institute, will succeed Dr. J. E. Stead as president of the organization, is to be formally elected at the May, 1922 meeting. Like Dr. Stead, the present president, Mr. Samuelson comes from Middlesbrough. He is the second son of the late Right Hon. Sir Bernard Samuelson, Bart, P. C. F. R. S., eighth president of the Iron and Steel Institute. Sir Bernard was one of the founders of the Cleveland iron trade and sat for many years in the house of commons, being regarded as a special authority on technical education. The president-elect who was born in 1861, succeeded his father in the chairmanship of Sir B. Samuelson & Co., Ltd., ironmasters.

BUY IT FROM THE NAVY

Naval Vessels as Hulks for Salvage

By Sealed Proposals opening January 16, 1922
At Board of Survey, Appraisal and Sale,
Navy Yard, Washington, D. C.

Improvements in Naval construction have rendered these fine old warships obsolete, and the opportunity is now being given the metal trades to purchase for salvage the following vessels:

Some of the Vessels Offered for Salvage

(Note.—Displacement given below is for full load.)

U. S. S. MAINE (Battleship). Built in 1901.
Length, 393 feet; draft, 23 feet; beam, 72 feet.
Displacement, 13,500 tons. Now at Philadelphia, Pa.

U. S. S. MISSOURI (Battleship). Built in 1901.
Length, 394 feet; draft, 24 feet; beam, 72 feet.
Displacement, 13,500 tons. Now at Philadelphia, Pa.

U. S. S. WISCONSIN (Battleship). Built in 1898.
Length, 374 feet; draft, 24 feet; beam, 72 feet.
Displacement, 12,150 tons. Now at Philadelphia, Pa.

*U. S. S. BROOKLYN (Cruiser). Built in 1895.
Length, 402 feet; breadth, 65 feet; draft, 24 feet.
Displacement, 10,068 tons. Now at Mare Island, Calif.

*U. S. S. COLUMBIA (Cruiser). Built in 1892.
Length, 413 feet; draft, 23 feet; beam, 58 feet.
Displacement, 7,387 tons. Now at Philadelphia, Pa.

U. S. S. MEMPHIS (Cruiser). Built in 1903.
Length, 504 feet; draft, 25 feet; beam, 73 feet.
Displacement, 15,712 tons.
Now a wreck at Santo Domingo, D. R.

TARGET (Ex-Monitor PURITAN). Built in 1882.
Length, 299 feet; draft, 18 feet; beam, 60 feet.
Displacement. 6,060 tons. Now at Norfolk, Va.

U. S. S. OZARK (Monitor). Built in 1900.
Length, 255 feet; draft, 13 feet; beam, 50 feet.
Displacement, 3,356 tons. Now at Philadelphia, Pa.

TARGET (Ex-Monitor MIANTONOMOH). Built in 1876.
Length, 263 feet; draft, 14 feet; beam, 55 feet
Displacement, 3,990 tons. Now at Norfolk, Va.

U. S. S. TONOPAH (Monitor). Built in 1900.
Length, 255 feet; draft, 13 feet; beam, 50 feet.
Displacement, 3,356 tons. Now at Philadelphia, Pa.

*U .S. S. SMITH (Destroyer). Built in 1909.
Length, 294 feet; draft, 8 feet; beam, 26 feet.
Displacement, 902 tons. Now at Philadelphia, Pa.

*U. S. S. ALBERT BROWN (Fish Boat). Built in 1897.
Length, 103 feet; draft, 10 feet; beam, 18 feet.
Gross tonnage, 108 tons. Now at Philadelphia, Pa.

U. S. S. ORIOLE (Ex-DALE); Wooden Sailing Vessel. Built in 1839.
Length, 117 feet; beam, 34 feet.
Now at Coast Guard Depot (S. Baltimore, Md.)

NOTE—The vessels marked with an asterisk (*) will on December 15, 1921, be offered for sale for "Conversion to Commercial Uses." Such vessels as are not sold on that date will be offered on January 16, 1922, for sale as "Hulks for Salvage."

The offer of these vessels by the Navy Department for sale to commercial organizations should be considered from the standpoint of a nucleus to go into the ship breaking up field for some "far-sighted concern" looking for new business.

Aside from the ferrous and non-ferrous metals entering into Naval ship construction, consider the electrical machinery, pumps, winches, boilers, engines, piping, etc., for which there is always a receptive market with an attractive recovery.

A careful investigation of the success recently achieved in foreign countries by "ship breaking" concerns will convince you of the advisability of promptly communicating with the Navy Department.

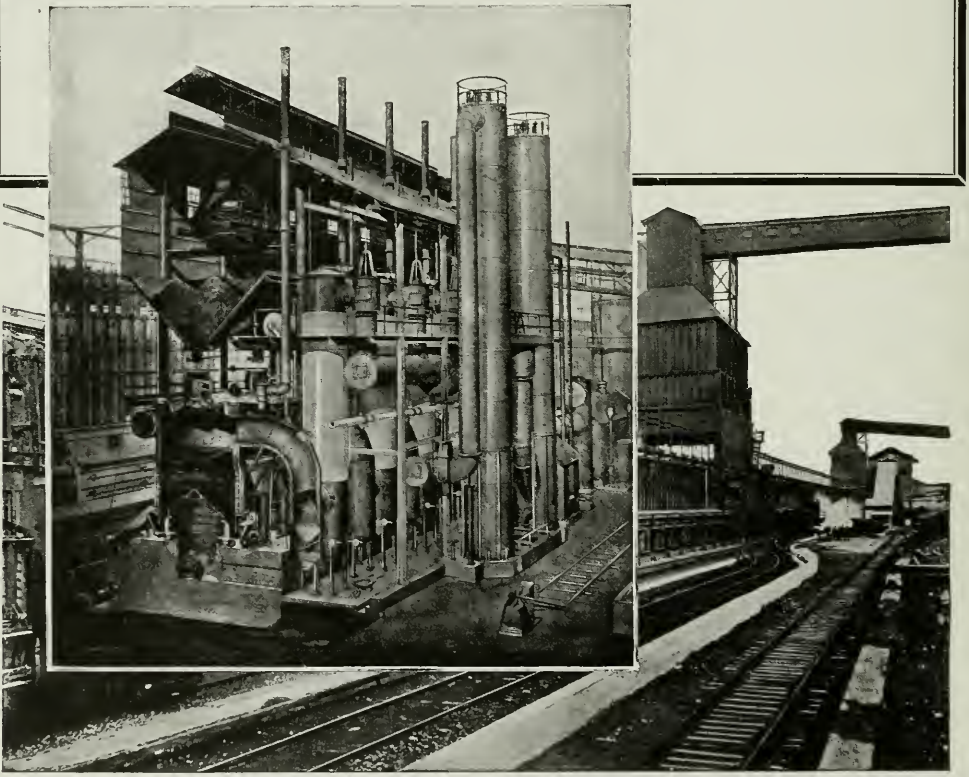
Write or wire for catalog No. 25-46b giving the terms of sale and describing the vessels offered.

Central Sales Office

NAVY DEPARTMENT **WASHINGTON, D. C.**

FOR THE STEEL PLANT

KOPPERS COMBINATION COKE AND GAS OVENS AND KOPPERS-KERPELY GAS PRODUCERS



THE KOPPERS COMPANY

PITTSBURGH, PA.

Some Pointers on By-Product Coke Oven Operations

COKE PLANT CHANGES OWNERSHIP

The American Rolling Mill Company and the Whitaker-Glessner Company have jointly acquired all the capital stock of the Portsmouth Solvay Coke Company and have reorganized the company. The name has been changed to the Portsmouth By-Product Coke Company. The main office will be at Portsmouth Ohio, where the by-product coke ovens are located.

The officers of the reorganized company are: President, J. H. Frantz, Columbus, Ohio; vice president, R. H. Sweetser, Columbus, Ohio; secretary-treasurer, H. K. Moore, Portsmouth, Ohio; auditor, J. L. Watkins, Portsmouth, Ohio; superintendent of coke ovens L. D. Huestis, Portsmouth, Ohio.

The Portsmouth By-Product Coke Company owns and operates Freeburn mine in Pike County, Kentucky. Mr. Thomas DeVenny is superintendent of the coal mine. Freeburn mine furnishes high-grade by-product coal to the coke ovens at Portsmouth and also furnishes steam coal to the trade.

TRANSPORTING ORE ON THE MISSISSIPPI.

Towing of iron ore and coal on the Upper Mississippi is assured for next year. The fleet of steel tow boats constructed under authorization of the Shipping Board Emergency Fleet Corporation for up river transportation passed down the Upper Mississippi the last of October from Stillwater, Minnesota, where they have been under construction since the spring of 1920. They are all done but the finishing touches and these will be put on at St. Louis. With the opening of navigation next spring the new craft will tow barges of 2,500 tons capacity each in strings of three, transporting coal north from St. Louis to St. Paul and Iron ore from the Mesaba Range district of Minnesota south.

The boats have been christened the Minnesota, Missouri, Iowa and Illinois, and have been leased together with the big nineteen steel barges to the Mississippi Valley Iron Company of St. Louis. Field Goitra, son of Edward Goitra, president of the Mississippi Valley Iron Company, was aboard the boats on their maiden trip downstream. Many notables were passengers, among them some of the leading engineers of the country. One was William S. Mitchell, the naval architect who designed the craft and supervised their construction.

The four boats, unlike any other seen on the Upper Mississippi made an imposing sight as they passed downstream together. As they cost approximately $360,000 each, the whole tow was undoubtedly the most valuable that has ever been on the upper reaches of the Father of Waters. The contract was the largest single one ever let for inland water craft and was completed conjointly by the three firms, Minneapolis Steel and Machinery Company, St. Louis Boat and Engineering company and the Marietta Manufacturing Company, Point Pleasant, Virginia.

The boats have been specially designed for navigation of the Upper Mississippi. They are 265 feet long over all with a 58-foot beam and draw a maximum of four feet. While designed for burning coal a change of pipe fittings will convert them into oil burners. The wheels are stern type and much larger than the wheels of craft now on the Upper River, having dimensions of 40 x 22. There is a spud directly in front of the pilot house 30 feet long. When the boat is in difficulty, this can be dropped to bottom and act as an anchor. The engines are of the compound condensing type and of 1,800 horsepower. As boats are not designed for passenger and freight traffic comparatively small space is given to cabins. About 25 officers and men will constitute the crew. There are eleven double state rooms besides quarters for the men. The boats have refrigeration plants, electric lights and clarifying and softening water systems. On second deck forward is the captain's office with complete office equipment. The room commands front view of river. An inter-communicating telephone system gives immediate connection with all parts of the ship.

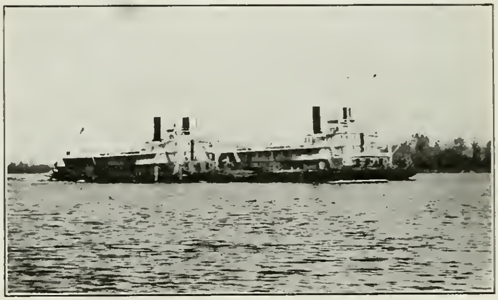


Fig. 1.

The pilot house is a model of its kind. The Steering engine operated by either air or steam with tiller lines rigged to wheel, make it accident proof. Searchlights are operated from the pilot house. Each boat carries a gasoline launch so that it will not be necessary to land for mail and minor supplies. Five ton derricks are used as davits. All decks and superstructure of the boats are of steel.

NEW BOOK ON COVE-OVEN INDUSTRY

T. Biddulph-Smith is the author of "Coke-Oven and By-Product Works Chemistry," recently published by Charles Griffin & Co., Ltd.

For many years crude tar and sulphate of ammonia were the only subsidiaries of the by-product coking industry. The present position of the industry represents a great advance on these conditions, and the modern coke-oven chemist must be alive to the possibilities of an ever-extending field of operation. The realization of the value of benzol and, more recently, of alcohol from coke-oven gas as motor spirit, of coke-oven gas as an important factor in modern lighting problems, and of toluene in the high explosives industry, is in keeping with this extension; and, more over, the chemical efficiency of a coke-oven plant is a factor of which the value is more fully realized year by year. In view of these facts and of the undoubted scarcity of text-books dealing with this specific subject the work is opportune.

The book is a useful work of reference for the more advanced chemist; a study of its contents will give the average student a valuable insight into the chemistry of a modern coke-plant and, more especially, into that of the by-products.

TRADE NOTES

F. J. Ryan & Company, Wesley Building, Philadelphia, specialists in industrial heating problems announce the closing of furnace contracts as follows:

Electric Manganese Steel Company,
U. S. Cast Iron Pipe & Foundry Co.,
Crucible Steel Castings Company:
These are operated under the Mires Oil Burning Systems.

Armstrong Cork Company,
Penna. Prison Bureau,
George W. Tyrell Company:
These are operated under the Mires Electric Heating Systems.

The Powdered Coal Development Corporation has been organized with headquarters at Omaha, Nebraska. This company controls the Pruden patents for the burning of pulverized coal in the western half of the United States.

The Universal Crane Company of Elyria, Ohio, announce the appointment of Mr. George L. Sawyer, formerly sales manager of material handling machinery for Barber-Greene Company, as their representative in the New York field. His offices will be at 141 Center Street, New York City.

The Conveyors Corporation of America, Chicago, have issued a new folder describing their American Air Tight Door, a cast iron door of exceptional design and build. Air tight, its use is desirable for ash pits, boiler settings, coke ovens, core ovens, bake ovens, oil stills, dryers, retorts and kilns.

H. V. Schiefer has been placed in charge of the Philadelphia office of The Webster Mfg. Company of Chicago. He has had wide experience in equipment for handling materials, having been affiliated with the C. O. Bartlett & Snow Co., Cleveland, as Chief Draftsman; Messe & Gottfried Co., San Francisco, as Chief Engineer; The Grasselli Chemical Company, Cleveland, as Labor Saving Engineer; and the Arthur G. McKee Co., Cleveland, as Manager of Sintering Plant department. He has contributed freely to the technical press on the subjects of material handling and the sintering of blast furnace flue dust.

W. A. Jones Foundry & Machine Co., manufacturers of power transmitting machinery, announce the appointment of Mr. Fred E. Holtz as their Milwaukee district representative. He will assume his new duties immediately, making headquarters in the First National Bank Building.

Detroit Seamless Steel Tube Company, of Detroit, Mich., announce the appointment of Mr. C. H. Hobbs as asst. general manager of sales. Mr. Hobbs has been with the Lackawanna Steel Co. for over fourteen years.

TRADE PUBLICATIONS

The Stromberg Electric Co., Chicago, Ill., have just issued Bulletin No. 55 describing their "Process Timing and Signalling Instruments." These instruments have been developed to meet the demand for accurate and thoroughly dependable means of automatically operating a signal at the end of a predetermined time, to announce the completion of a process or operation, and has a very broad field of application.

Pawling & Harnischfeger Company, Milwaukee, Wis., have issued Bulletin 56X describing P. & H. Excavating Equipment. This booklet summarizes the achievements of this equipment in road building, irrigation and reclamation, trench and general excavation and in all phases of engineering activity in which earth handling is the prime factor.

W. S. Rockwell & Company, New York, N. Y., in Bulletin No. 239 just issued show an improved type of forge furnace to meet the demand for equipment which will lower production cost. The novel features of the furnace consists of means for better application for heat, protection of the operator, and utilization of waste gases to preheat air and fuel for combustion.

Bulletin No. 206, dated October, 1921, is a new publication illustrating and describing P. & H. Radial Wall Drills made by Pawling & Harnischfeger Co. of Milwaukee. Examples of interior and exterior drilling of large steel drums, and the drilling and reaming of structural material are shown as well as dimension drawings and data. Page 8 is crowded with a list of users of P. & H. Horizontal Drilling and Boring Machines, among them being Allis Chalmers, Bethlehem Steel Co., Lackawanna Bridge Co., General Electric Co., U. S. Navy Yard, Bullard Machine Tool Co., Los Angeles Shipbuilding and Dry Dock Co., etc. etc.

The Pawling & Harnischfeger Company have issued a new bulletin on the P. and H. No. 6 Radial Wall Drill. This drill is designed to meet the demand for a simple and effective machine for drilling, reaming and counter-sinking large unwieldy pieces, such as structural shapes, boiler plates, long beams and similar bulky objects.

Whiting Corporation have issued a new crane catalogue No. 158 to supersede No. 151. The catalogue describes and illustrates this company's standard crane designs.

"Nordberg and the Mining Industry," is the title of a new 9 in. x 12 in., 16 pages and cover booklet issued by the Nordberg Manufacturing Company.

The booklet illustrates the plants of 15 mining companies, gives data concerning their production of copper, gold and silver, mentions the capitalization, assets and dividends of each plant and briefly describes the important equipment, including the Nordberg apparatus, in use.

The Westinghouse Electric & Manufacturing Company has issued leaflet 1732, which describes and illustrates enclosed float switches. These float switches are used on motor operation pumps, to automatically maintain a water level in open tank, reservoir or sump system and to prevent the water from rising above a predetermined level.

Electric Motor Drive for Power Pumps is the title of leaflet 1950 which is being distributed by the Westinghouse Electric & Manufacturing Company. This leaflet gives a discussion of the advantages of the use of electricity for this work, and it specifically points out the type of motor which should be used.

Atlas, Ideal and Victor Reducing Valves, Pump Governors, Pressure Regulators, Hot Water Tank Regulators, Control Valves and Damper Regulators are described in Junior Catalogue No. 21 just published by the Atlas Valve Company, 282 South Street, Newark, N. J. This little catalogue of 20 pages gives complete information — illustrates, describes, lists all sizes and gives prices. A copy will be sent free on request to any reader of this publication.

Bulletin No. 234. "The Continuous Heat Treatment of Metals with Automatic and Semi-Automatic Furnaces" is the fourth of the series dealing with fundamentals that influence the quality and cost of heated products issued by W. S. Rockwell Co., 50 Church St., New York.

The Vacuum Oil Company has just issued two educational publications prepared by their Technical Department. The first of these entitled "Stationary Steam Engines" with the sub-title "Steam Valve and Cylinder Lubrication" will be especially interesting to readers of "Combustion" as shown by the following outline: Part I—Reciprocating Steam Engines: Introduction; Classification; Factors of Steam Engine Operation; Mechanical Principles; Lubrication; Selection of Cylinder Oil; Selection of Bearing Oil. Part II—Boiler Plant and Steam Production; Boiler Plant; Steam Quality; Exhaust Steam; Oil in Exhaust Steam; Extraction of Oil; Feed Water Treatment. The second is entitled "Oil Engines, Surface Ignition Type" and considers the Classification, Principle, Operation, and Lubrication of this type of engines. Copies will be furnished upon request.

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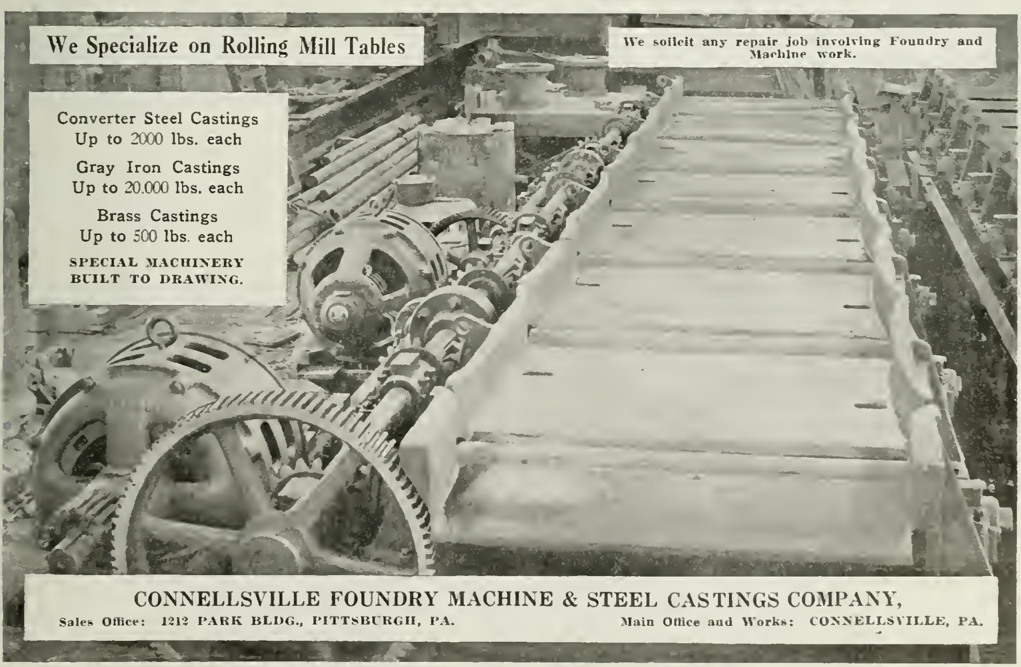

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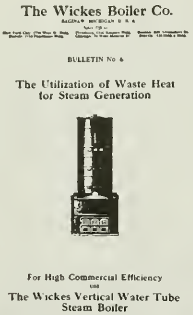

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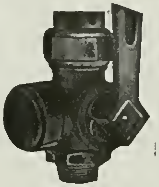

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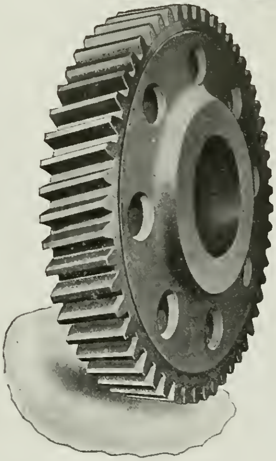

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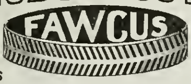

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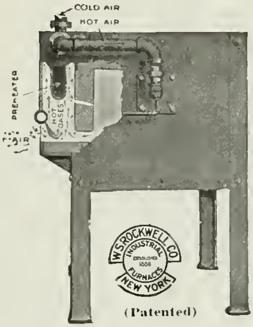

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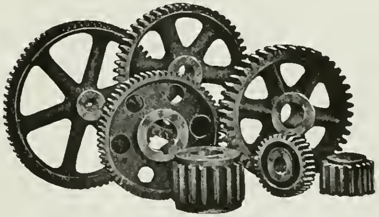

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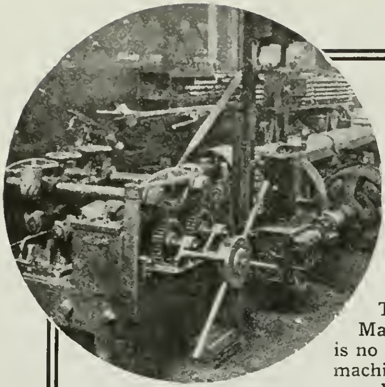

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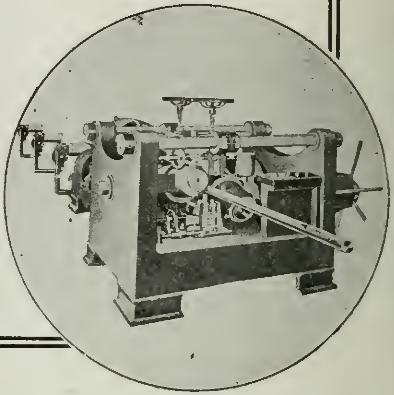

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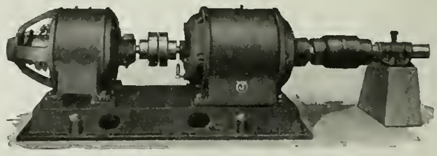

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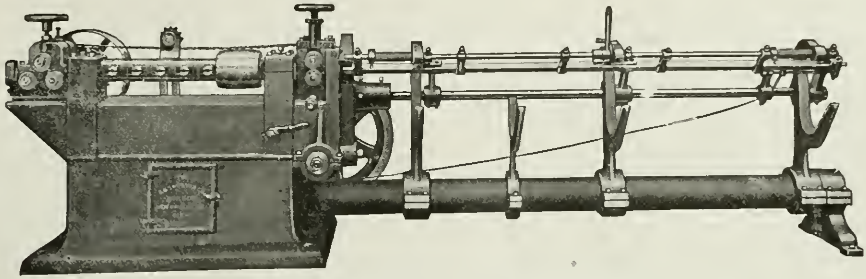

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Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
United Eng. & Foundry Co.
Riter-Conley Co.

Acid-Proof Products.
Johns-Manville Co.

Acid Tanks.
Blaw-Knox Co.
Kellogg, M. W. Co., The
Riter-Conley Co.

Acoustics.
Johns-Manville Co.

"Adamite."
Pittsburgh Iron & Steel Fdys. Co.
United Eng. & Fdy. Co.

Agitators.
Blaw-Knox Co.
Chapman Eng. Co.
Riter-Conley Co.

Air Compressors.
Allis-Chalmers Mfg. Co.
Blaw-Knox Co.
General Electric Co.
Ingersoll-Rand Co.
Mesta Machine Co.
Westinghouse Elec. & Mfg. Co.

Air Valves.
Felix McCarthy.

Alloys.
Otis Steel Co., The
U. S. Reduction Co.

Aluminum.
U. S. Reduction Co.

Ammonia Distillation Plants.
Semet-Solvay Co.

Ammonia Recovery Apparatus.
The Koppers Co.

Annealing Boxes.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Blaw-Knox Co.
Kellogg, M. W. Co., The
Mesta Machine Co.
United Eng. & Fdy. Co.

Annealing Boxes and Carriers.
Blaw-Knox Co.

Annealing Furnaces and Ovens.
General Electric Co.
Electric Furnace Constr. Co.
Rockwell Co., W. S.
Westinghouse Elec. & Mfg. Co.

Annealing Pots—Forge and Hammer.
Blaw-Knox Co.
Kellogg, M. W. Co., The.

Annealing Pots—Lap Welded.
Blaw-Knox Co.
Kellogg, M. W. Co., The.
Riter-Conley Co.

Appliances—Steel Works.
Felix McCarthy.

Asbestos Materials.
Johns-Manville Co.

Automatic Air Dump Cars.
Clark Car Co.

Automatic Buckets.
Orton & Steinbrenner Co.

Automatic Gas Producers.
Wood, R. D. & Co.

Automatic Safety Stops.
Morgan Construction Co.

Automatic Smokeless Furnaces.
Babcock & Wilcox Co., The.
Westinghouse Electric & Mfg. Co.

Bakelite Micarta Gearing.
Nuttall, R. D. Co.

Babbitt Metal.
Allan & Son, A.
Lubricating Metal Co.

Baffles.
Johns-Manville Co.

Bands.
West Leechburg Steel Co.

Bar Straightening Machines.
Medart Patent Pulley Co.
Shuster Co., F. B.

Basic Open Hearth Steel.
Brier Hill Steel Co.

Beams.
Kratzer & Co., W. N.

Bearings and Bearing Metal.
Lubricating Metals Co., The.

Bearings—Roller.
American Roller Bearing Co.
Hyatt Roller Bearing Co.

Belting—Chains.
Morse Chain Co.

Belting—Silent Chain.
Morse Chain Co.

Benches—Draw Wire, Rivet and Bolt Works.
Morgan Construction Co.

Benzol Recovery Plants.
The Koppers Co.

Billets—Steel.
Brier Hill Steel Co.

Blast Furnaces.
McKee Co., Arthur G.
Meehan Boiler & Constr. Co.
Riter-Conley Co.

Blast Gates.
Rockwell, W. S. Co.

"Blaw" Buckets.
Blaw-Knox Co.

Blocks—Die.
American Steel Foundries.
Heppenstall Forge & Knife Co.

Blowers—Turbine.
General Electric Co.
Ingersoll-Rand Co.
Westinghouse Elec. & Mfg. Co.

Boilers.
Babcock & Wilcox Co., The
Badenhausen, Phillips.
Edge Moor Iron Co.
Ladd Co., Geo. T.
Meehan Boiler & Construction Co.
Springfield Boiler Co.
Wickes Boiler Co.

Boiler Insulation.
Johns-Manville Co.
Celite Products Co.

Boiler Settings.
Ladd Co., Geo. T.
Hydraulic Press Brick Co.

Boiler Wall Coating.
Johns-Manville Co.

Boilers—Water Tube.
Babcock & Wilcox Co., The.
Edge Moor Iron Co.
Ladd Co., Geo. T.
Meehan Boiler & Construction Co.
Springfield Boiler Co.
Wickes Boiler Co.

Boxes — Annealing Furnace and Oven.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Mesta Machine Co.
United Engineering & Fdy. Co.

Brakes—Electric, Magnetic, Crane.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.

Brake Band Lining.
Johns-Manville Co.

Brakes—Disc.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Medart Patent Pulley Co.

Brakes—Motor Operated.
Cutler-Hammer Mfg. Co.

Brick—Chrome, Magnesia, Silica.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Harbison-Walker Ref. Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Taylor, Chas., The Sons Co.

Brick—Blast Furnace.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Ashland Fire Brick Co.
Clearfield Brick Mfg. Co.
Dover Fire Brick Co.
Eureka Fire Brick Works.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Kier Fire Brick Co.
Mutton Hollow Fire Brick Co.
Paterson Fire Brick Co.
Pyro Clay Products Co.
Soisson Fire Brick Co., Jos.

Brick—Boiler Settings.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Ashland Fire Brick Co.
Clearfield Brick Mfg. Co.
Dover Fire Brick Co.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Kier Fire Brick Co.
Mutton Hollow Fire Brick Co.
Paterson Fire Brick Co.
Pyro Clay Products Co.
Soisson Fire Brick Co., Jos.
Taylor, Chas., The, Sons Co.

Brick—Fire.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Ashland Fire Brick Co.
Clearfield Brick Mfg. Co.
Crescent Refractories Co.
Dover Fire Brick Co.
Eureka Fire Brick Works.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Kier Fire Brick Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Soisson Fire Brick Co., Jos.
Taylor, Chas., The Sons Co.

Brick—Heat Insulating.
Amer. Enameled Brick & Tile Co.
Celite Products Co.
Eureka Fire Brick Works.
Johns-Manville Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Taylor, Chas., The Sons Co.

Brick—Locomotive Fire.
Amer. Enameled Brick & Tile Co
Clearfield Brick Mfg. Co.
Dover Fire Brick Co.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Taylor, Chas., The Sons Co.

Brick—Nozzles, Sleeves and Runner
Amer. Enameled Brick & Tile Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.

Boiler Feed Purification.
Scaife, Wm. B. & Sons Co.

Boiler Tubes.
Colonial Supply Co.

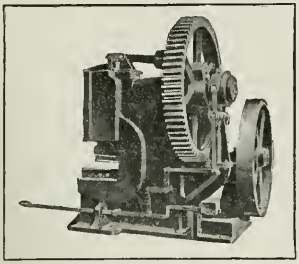
Boxes—Annealing Furnace & Oven.
Kellogg, M. W. Co., The

Bridges and Structural Works.
Blaw-Knox Co.
Kratzer & Co., W. N.
Meehan Boiler & Construction Co.
Mt. Vernon Bridge Co.

Buckets—Clam Shell, Grab or Orange Peel for Coal and Ore.
Blaw-Knox Co.
Edgar E. Brosius.

Buckstays—O. H.
Blaw-Knox Co.
National Roll & Fdy. Co.

Buildings.
Blaw-Knox Co.
Kratzer & Co., W. N.
Mt. Vernon Bridge Co.



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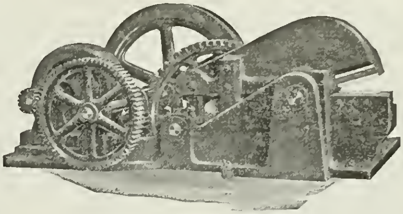

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Blaw-Knox Co.

Bulkheads—O. H.
Blaw Knox Co.
National Roll & Fdy. Co.

Bulldozers.
Garrison Foundry Co., A.
Morgan Construction Co.

Buoys.
Riter-Conley Co.

Burners—Gas and Oil.
Rockwell Co., W. S.

By-Product Coke and Gas Oven Plants.
Koppers Co., The.
Semet-Solvay Co.

Caissons.
Riter-Conley Co.

Cars—Dump.
Clark Car Co.
Treadwell Engineering Co.
Youngstown Fdy. & Mch. Co.

Cars—Extension Side Dump.
Clark Car Co.

Cars—Forging and Charging Box.
Treadwell Engineering Co.

Cars—Hot Metal.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Pennsylvania Eng. Works.
Treadwell Engineering Co.
Youngstown Fdy. & Mch. Co.

Cars—Ingot—Slag—Billet.
Birdsboro Steel Fdy. & Mch. Co.
Pennsylvania Eng. Works.
Treadwell Engineering Co.

Cars—Industrial.
Treadwell Engineering Co.
Youngstown Fdy. & Mch. Co.

Cars — Ingot and Open Hearth Charging.
Treadwell Engineering Co.

Cars—Ladle Transfer.
Treadwell Engineering Co.
Youngstown Fdy. & Mch. Co.

Car Tanks.
Blaw-Knox Co.
Kellogg, M. W. Co., The
Riter-Conley Co.

Cartridge Fuses—Renewable and Non-Renewable.
D. & W. Fuse Works of General Electric Co.
Johns-Manville Co.

Castings—Annealed, Semi-Steel.
McLain's System, Inc.

Castings.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.

Castings—Brass.
Connellsville Fdry. Mach. & Steel Casting Co.

Castings—Brass and Bronze.
Mesta Machine Co.

Castings—Chill.
McLain's System, Inc.

Castings—Electric Steel.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Treadwell Engineering Co.
Wheeling Mold & Foundry Co.

Castings—Electric Process.
Treadwell Engineering Co.

Castings—Gear.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Connellsville Fdry. Mach. & Steel Casting Co.
Garrison Foundry Co., A.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Engineering Co.
Taylor-Wilson Mfg. Co.
Treadwell Engineering Co.
United Engineering & Fdy. Co.
Wheeling Mold & Foundry Co.

Castings—Machinery.
Connellsville Fdry. Mach. & Steel Casting Co.

Castings—Semi-Steel.
McLain's System, Inc.

Castings—Gray Iron and Steel.
Garrison Foundry Co., A.
Morse Chain Co.
Otis Steel Co., The.
Nuttall & Co., R. D.
Taylor-Wilson Mfg. Co.
Treadwell Engineering Co.

Castors—Plate Mill.
Treadwell Engineering Co.

Cement—Fire Brick.
American Refractories Co.
Crescent Refractories Co.

Cement—Furnace—High Temperature.
Johns-Manville Co.

Central Station Equipment.
Allis-Chalmers Mfg. Co.
General Electric Co.
Morgan Construction Co.
Smith Gas Engineering Co.
Westinghouse Electric & Mfg. Co.

Chains—Agricultural.
Morse Chain Co.

Chains—Automobile, Engine.
Morse Chain Co.

Chain Blocks.
Morse Chain Co.

Chains—Bicycle (Twin Roller)
Morse Chain Co.

Chain Grates.
Hagan, Geo. J. Co.

Chain—Power Transmission.
Morse Chain Co.

Chain Drives.
Morse Chain Co.

Chains—Sprocket Wheel.
Morse Chain Co.

Chains—Silent.
Morse Chain Co.

Channels.
Kratzer & Co., W. N.

Charging Buggies.
Treadwell Engineering Co.

Charging Boxes.
Blaw-Knox Co.
Riter-Conley Co.

Chimneys—Radial Brick.
Kellogg, M. W. Co., The

Chimneys—Steel.
Kratzer & Co., W. N.

Chrome.
Harbison-Walker Refractories Co.

Chrome Brick.
American Refractories Co.

Circulating Systems for Lubricating Oil.
Bowser & Co., Inc., S. F.

Clutches—Magnetic.
Cutler-Hammer Mfg. Co.

Coal.
Combustion Eng. Corp.
McKeefrey & Co.
Stewart Iron Co.

Coal Pulverizers.
Fuller Engineering Co.

Coal Crushers.
Orton & Steinbrenner Co.

Coal Gas Plants.
U. G. I. Contracting Co.

Coal—Plants for Powdering.
Blaw-Knox Co.
Fuller Engineering Co.

Coal Tipples and Trestles.
Blaw-Knox Co.
Mt. Vernon Bridge Co.

Cocks—Tuyere.
McCarthy, Felix.
Homestead Valve Mfg. Co.

Coils and Bends—Pipe.
Pittsburgh Piping & Equip. Co.

Coke.
McKeefrey & Co.
Stewart Iron Co.

Coke Breeze.
Combustion Eng. Corp.
Garrison Foundry Co., A.
Mesta Machine Co.
National Roll & Foundry Co.
Otis Steel Co., The.
Standard Engineering Co.
Treadwell Engineering Co.
United Eng. & Fdy. Co.
Wheeling Mold & Foundry Co.

Coke Ovens — By-Product—Cross Regenerators.
Hydraulic Press Brick Co.
Koppers Co., The.

Cooling Tables.
Blaw-Knox Co.

Columns.
Kratzer & Co., W. N.
Meehan Boiler & Construction Co.

Combination Gas Plants.
U. G. I. Contracting Co.

Compressed Air Locomotives.
Porter Co., H. K.

Compressors—Air.
Allis-Chalmers Mfg. Co.
Blaw-Knox Co.
General Electric Co.
Ingersoll-Rand Co.
Mesta Machine Co.
Westinghouse Elec. & Mfg. Co.

Concrete Construction.
McKee, Arthur G. & Co.

Concrete — Steel Forms for Construction.
Blaw-Knox Co.

Condensers.
Blaw-Knox Co.
Riter-Conley Co.

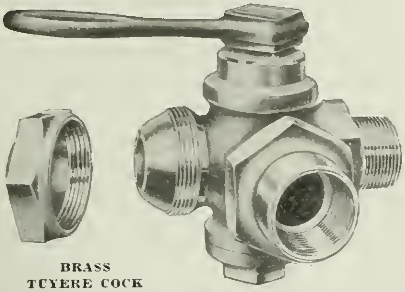
Condensers — Barometric, Surface Jet.
Ingersoll-Rand Co.
Kellogg, M. W. Co., The
Mesta Machine Co.
Westinghouse Electric & Mfg. Co.

Condensers—Low Level Set.
Ingersoll-Rand Co.

Condensers—Surface.
Ingersoll-Rand Co.

Connectors—Frankel Solderless.
Westinghouse Electric & Mfg. Co.

Constructing Engineers.
See—Seldon & Associates.
Dwight P. Robinson & Co., Inc.



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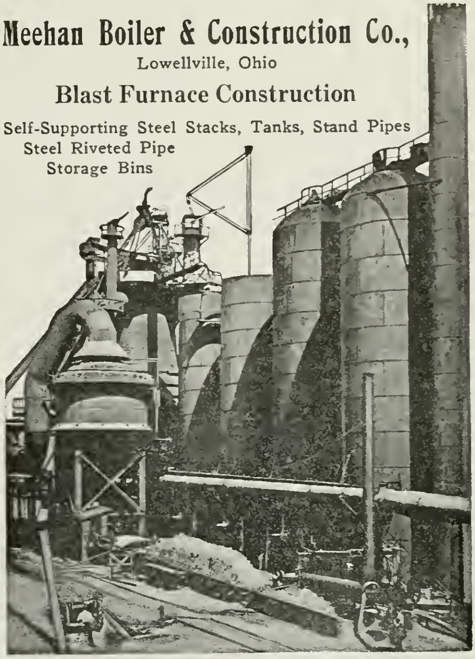

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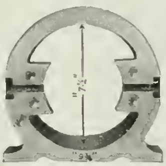

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Construction—Blast Furnace.
Blaw-Knox Co.
Freyn, Brassert & Co.
Laughlin & Sons Co., Alex.
Meehan Boiler & Construction Co.
McClure, G. W. & Son Co.
McKee, Arthur G. Co.
Mt. Vernon Bridge Co.
Riter-Conley Co.
Smythe & Co., S. R.

Construction—Gas Works.
Blaw-Knox Co.
Morgan Construction Co.
McKee, Arthur G. Co.
Riter-Conley Co.
Smith Gas Engineering Co.

Construction—Plate.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Riter-Conley Co.
Mt. Vernon Bridge Co.

Construction—Structural Iron, Steel
Blaw-Knox Co.
Kratzer & Co., W. N.
Meehan Boiler & Construction Co.
Mt. Vernon Bridge Co.

Construction—Wire Work.
Kratzer & Co., W. N.

Continuous Machines.
American Industrial Eng. Co.

Continuous Rolling Mills.
Treadwell Engineering Co.

Controllers—Automatic for Cranes.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Controllers—Enclosed Drum Type for Cranes.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Controllers—Electric, for Steel Mill Machinery.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Controllers — Manual, Automatic, Machine Tool, Crane, Coal and Ore Bridges.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Conveyors—Billet.
Treadwell Eng. Co.

Cooling Beds.
Treadwell Engineering Co.

Cooling Plates.
Blaw-Knox Co.

Core Ovens.
Electric Furnace Construction Co.

Coupling Boxes.
American Steel Foundries Co.
Garrison Foundry Co., A.
Mesta Machine Co.
National Roll & Foundry Co.
Standard Engineering Co.
Wheeling Mold & Foundry Co.

Couplings—Flexible.
Electric Controller & Mfg. Co.
Smith & Serrell.

Couplings—Magnetic.
Cutler-Hammer Mfg. Co.

Couplings—Shaft.
Morse Chain Co.
Smith & Serrell.

Couplings—Rigid.
Smith & Serrell.

Couplings—Compression Shaft.
W. H. Nicholson & Co.

Coverings for Cold Pipes.
Johns-Manville Co.

Coverings for Pipes and Boilers.
Celite Products Co.
Johns-Manville Co.

Cranes—Charging.
Alliance Machine Co.
Northern Engineering Works.

Cranes—Electric Traveling, Gantry and Grab Bucket.
Alliance Machine Co.
Manning, Maxwell & Moore, Inc.
Northern Engineering Works.
N. B. Payne & Co.

Cranes—Gantry.
Northern Engineering Works.

Cranes—Jib and Pillar.
Northern Engineering Works.

Cranes—Coal and Ash Handling.
Northern Engineering Works.

Cranes—Locomotive.
Orton & Steinbrenner Co.
U. S. Crane Co.

Cranes—Pillar.
Northern Engineering Works.

Cranes—Pneumatic.
Northern Engineering Works.

Cranes—Slag Breaking and Handling.
Northern Engineering Works.

Cranes—Transfer.
Northern Engineering Works.

Cranes—Wall and Jib.
Northern Engineering Works.

Cupolas.
Northern Engineering Works.
Pennsylvania Eng. Works.

Cupola Linings.
Johns-Manville Co.

Cupola Practice.
McLain's System, Inc.

Cutouts.
D. & W. Fuse Works of General Electric Co.
Johns-Manville Co.

Cut Bar Carrier.
Blaw-Knox Co.

Cyanide Pots.
Kellogg, M. W. Co., The

Cylinders.
Blaw-Knox Co.
Mesta Machine Co.

Designing and Construction Service
Dwight P. Robinson & Co., Inc.

Digesters.
Blaw-Knox Co.
Kellogg, M. W. Co., The
Riter-Conley Co.

Disc Brakes.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.

Direct Sulphate Plants.
Semet-Solvay Co.

Doors—Open Hearth.
Blaw-Knox Co.
National Roll & Foundry Co.

Draft Gauges and Recorders.
Bacharach Industrial Inst. Co.

Drag-line Excavators.
Orton & Steinbrenner Co.

Dredge Chain.
Morse Chain Co.

Drives—Chain.
Medart Patent Pulley Co.
Morse Chain Co.

Drives—Mill.
Fawcus Machine Co.

Dryers for all Materials.
Rockwell, W. S. Co.

Dynamos.
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Efficiency Instruments.
Bacharach Industrial Inst. Co.
Bristol Co.
General Electric Co.

Electric Light Equipment.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Electric Furnaces.
Blaw-Knox Co.
Electric Fur. Construction Co.
General Electric Co.
Pittsburgh Elec. Furnace Corp.
Pittsburgh Furnace Co.
W. S. Rockwell Co.
Westinghouse Elec. & Mfg. Co.

Electric Locomotives.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Electric Welding Apparatus.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Electrical Insulation.
Johns-Manville Co.

Elevators and Conveyors.
Orton & Steinbrenner Co.

Eliminators—Steam.
Nicholson & Co., W. H.

Engineering & Construction Service.
Dwight P. Robinson & Co., Inc.

Engineers—Consulting.
American Industrial Eng. Co.
Freyn, Brassert & Co.
Laughlin, Alex. & Co.
Arthur G. McKee Co.
McLain's System, Inc.
Moore, W. E. & Co.
Rockwell, W. S. Co.
See—Seldon & Associates.
Shover, Barton R.
Smythe Co., S. R., The

Engineers—Furnace.
Johns-Manville Co.
Electric Furnace Construction Co.
Moore, W. E. & Co.
Pittsburgh Electric Fur. Corp.
Rockwell Co., W. S.

Engineers and Contractors.
American Industrial Eng. Co.
Freyn, Brassert & Co.
Fuller Engineering Co.
Garrison A., Foundry Co.
Mesta Machine Co.
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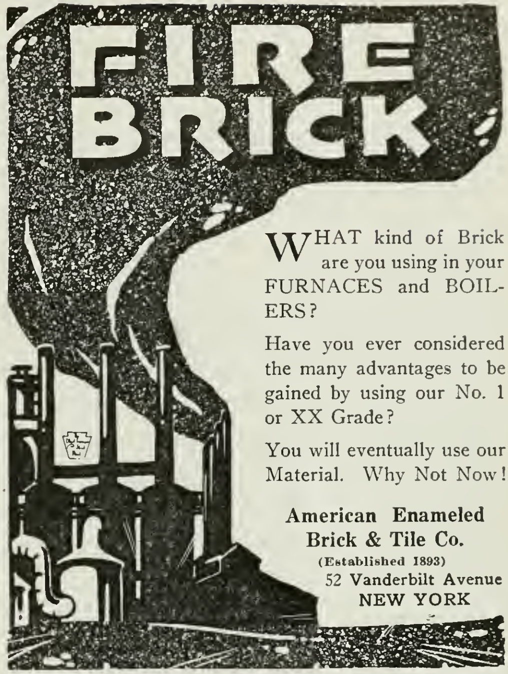

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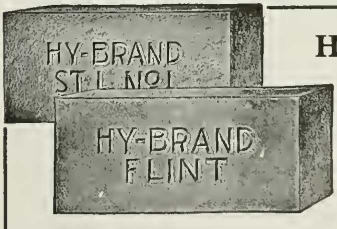

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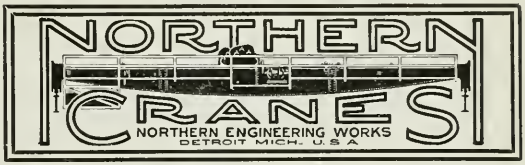

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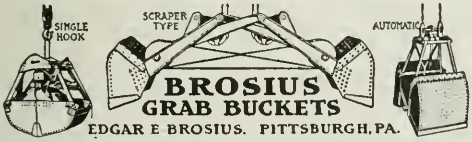

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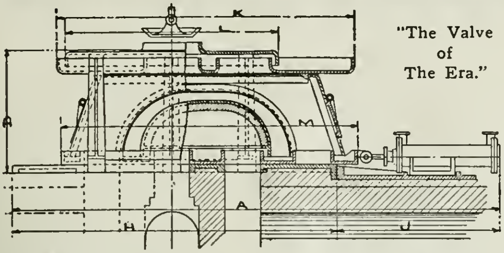

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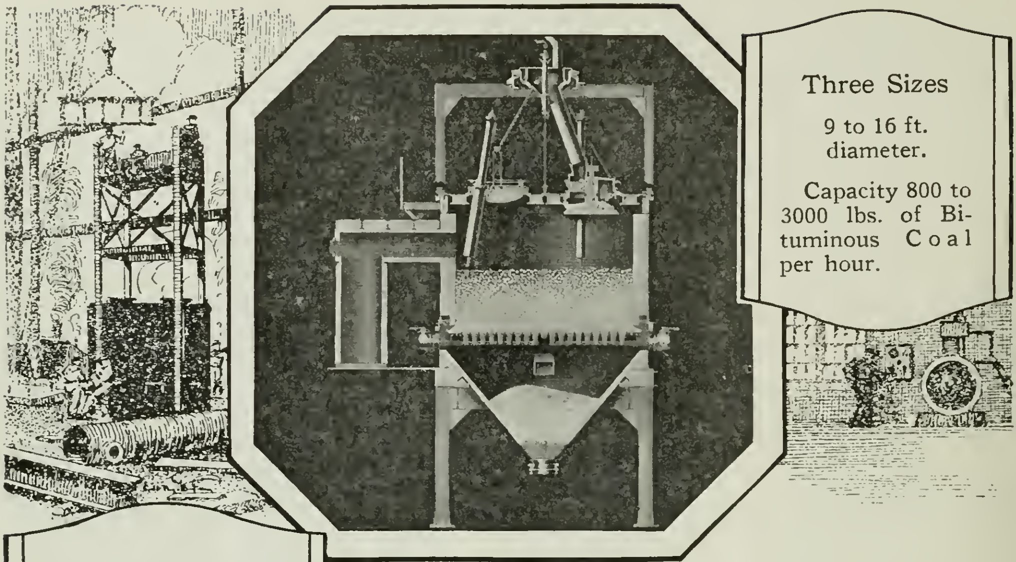

Three Sizes

9 to 16 ft. diameter.

Capacity 800 to 3000 lbs. of Bituminous Coal per hour.

Why

—Cold **Cleaned** Producer Gas?

Only cleaned producer gas:

—can be distributed through ordinary steel pipe and fittings just as natural or city gas is distributed, and therefore:

—permits centralizing the producer plant, and

—can be used for practically all heating operations, and

—can be used, in connection with gas engines for developing power.

A big capacity mechanically poked producer

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It Supplies—

COLD CLEANED PRODUCER GAS

99.5 % CLEANED

This heavy duty producer is in keeping with the present day idea of centralizing the producer, the investment in it, and the responsibility for it—a practice made possible by the development of Smith cleaned gas.

The illustration shows outstanding features of the Smith Type "G" Producer, the steam operated poker carried by the revolving top. Note that it is mounted in a revolving turret.

As the poker continually pierces the fuel bed, the poker turret and top revolve, so that every portion of the fuel bed is penetrated during a few revolutions of the top.

The top and turret revolve only when the poker is entirely withdrawn from the fuel bed, and consequently there is no side strain on the poker.

Besides greatly reducing operating labor, mechanical poking permits a deep fuel bed, four or five feet thick—an essential of successful clean-gas production. Type "G" has been proved in service and is made in the capacities listed above.

A detailed description, of the effective mechanical coal feed, and other features which reduce labor costs and increase the efficiency of the Type "G" producer, are contained in Bulletin 16.

Smith Gas Engineering Co., Dayton, Ohio
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